COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

October, 1946

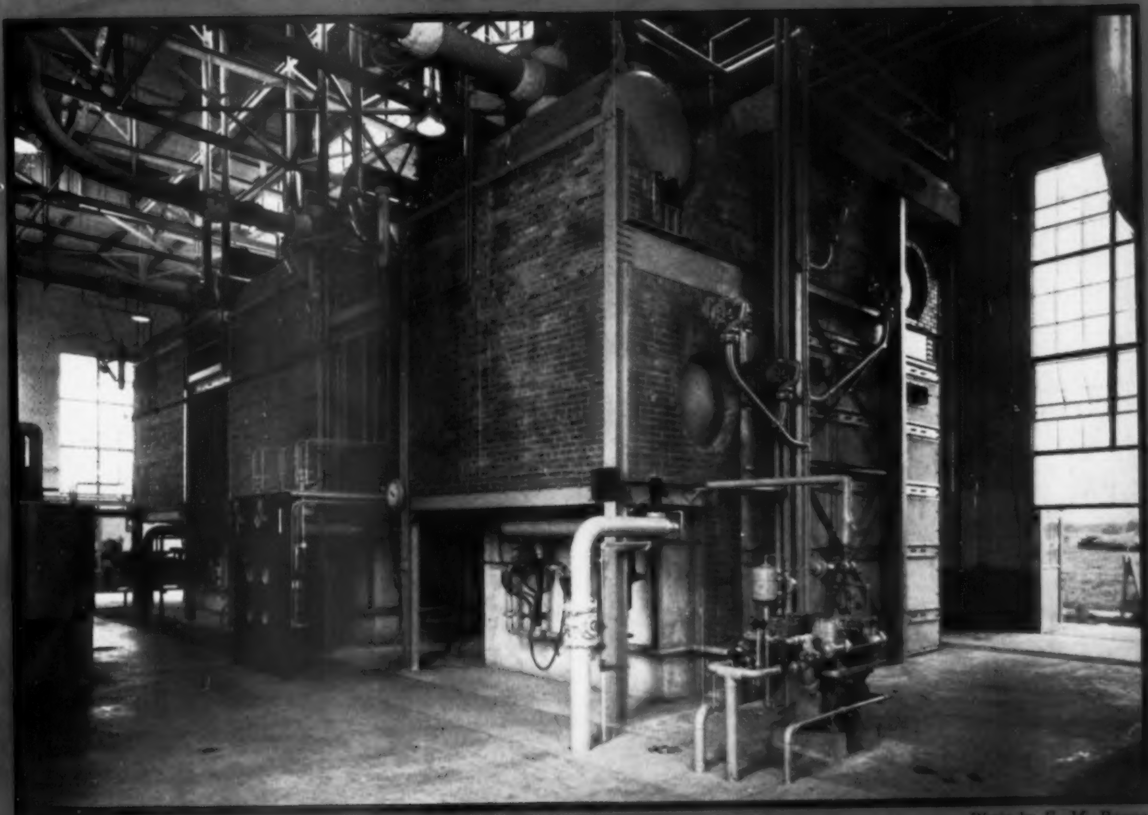


Photo by E. M. Payne

Boiler Room of a Veterans Hospital

Steam Generation at the New TIDD PLANT ▶

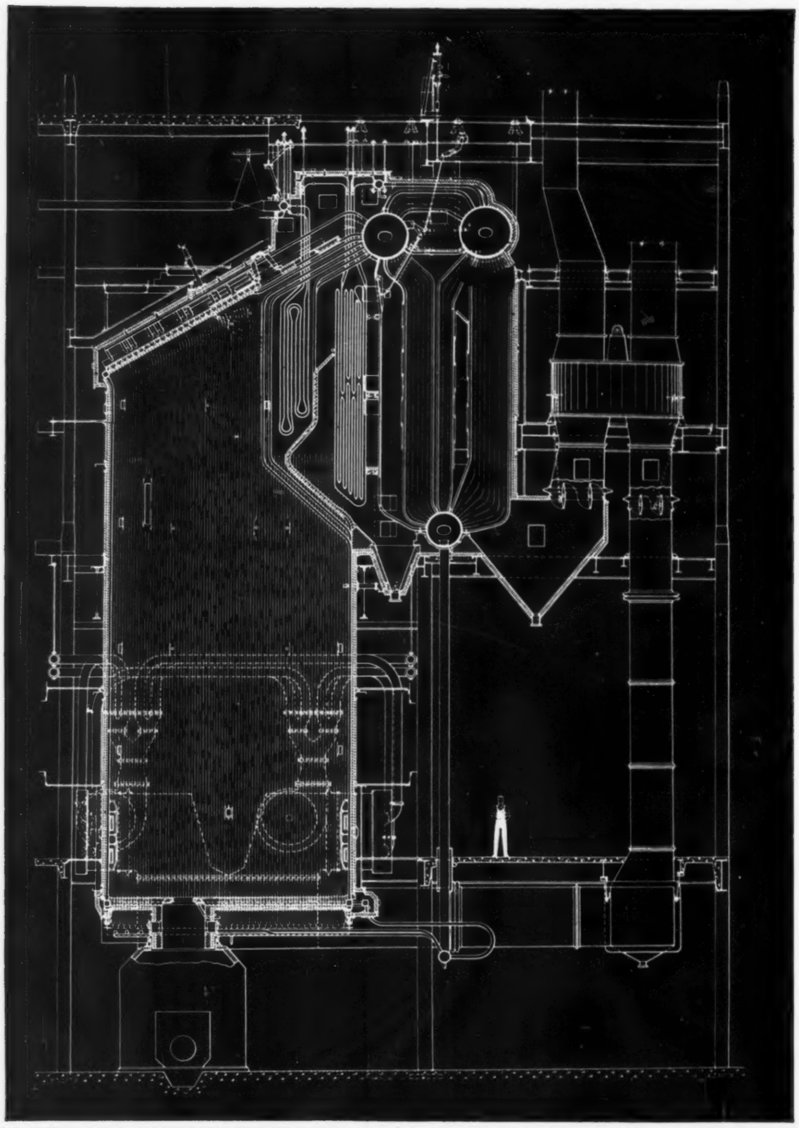
Insulation in the Design of Steam Generating Units ▶

A.S.M.E. Fall Meeting at Boston ▶

Recent C-E Steam Generating Units for Utilities

HARDING STREET STATION

INDIANAPOLIS POWER & LIGHT COMPANY



The C-E Unit, illustrated here, is now under construction at the Harding Street Station of the Indianapolis Power & Light Company.

A duplicate of one that was placed in service in this station in 1942, this unit is designed for a pressure of 975 psi, a total steam temperature of 900 F and a maximum, 24-hr. peak capacity of 400,000 lb of steam per hr.

The unit is pulverized coal fired using C-E Tangential Burners. The slag tap furnace is completely water cooled with bifurcated plain tubes on all walls. The Elesco Superheater is of the two-stage type. Superheat temperature control is assured over a wide range of rating by virtue of the thermostatically controlled bypass damper. Two Ljungstrom regenerative air heaters follow the boiler surface.

A-989

COMBUSTION ENGINEERING

200 MADISON AVENUE · NEW YORK 16, N. Y.

C-E PRODUCTS INCLUDE ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME EIGHTEEN NUMBER FOUR

CONTENTS

FOR OCTOBER 1946

FEATURE ARTICLES

EDITORIALS

JOHN L. WILLIAMSON, *General Representative*

ALFRED D. BLAKE, *Editor*

THOMAS E. HANLEY, *Circulation Manager*

Published monthly by COMBUSTION PUBLISHING COMPANY, INC., 200 Madison Ave., New York 16
A SUBSIDIARY OF COMBUSTION ENGINEERING COMPANY, INC.

Frederic A. Schaff, President; Charles McDonough, Vice-President; H. H. Berry, Secretary and Treasurer.

COMBUSTION is sent gratis to engineers in charge of steam plants from 500 rated boiler horsepower up and to consulting and designing engineers in this field. To others the subscription rate, including postage, is $2 in the United States, $2.50 in Canada and Great Britain and $3 in other countries. Single copies: 25 cents.

Issued the middle of the month of publication.

Publication office, 200 Madison Ave., New York CCA Member of the Controlled Circulation Audit, Inc.

Printed in U. S. A.

... yet holds high efficiency

CLOSE stabilization of water level is one of the factors permitting this utility plant to operate a Combustion Engineering Type VU boiler at 85-86 percent efficiency, despite an operating cycle which includes dead shutdown for eight to fourteen hours each night. Because of hydro-electric tie-in, the steam station generates only the amount of power required by industrial customers in excess of that available from the hydro system.

Rated capacity of the boiler is 100,000 pounds of steam per hour, peaks of 120,000 pounds per hour being carried for 30 to 45 minutes. During night shutdowns, the only steam generated is that bled through superheater tubes to keep them at proper temperature. Throughout the operating day, water level is held within plus-or-minus one inch by fully-automatic COPES Flowmatic Control.

The story is told in Performance Report Bulletin 455. Write for a copy—on your company letterhead, please.

NORTHERN EQUIPMENT COMPANY

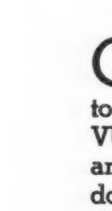
1066 GROVE DRIVE, ERIE 6, PENNSYLVANIA

Feed Water Regulators, Pump Governors, Differential Valves. Liquid Level Controls, Reducing Valves and Desuperheaters.

BRANCH PLANTS: Canada, England, France

Representatives Everywhere

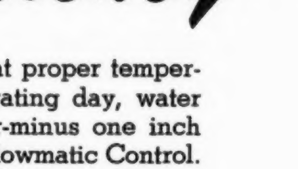
★ GET CLOSER LEVEL CONTROL WITH COPES FLOWMATIC



DESUPERHEATER...

Here's a desuperheater every bit as effective on light loads as at full capacity. No water dribbles into the steam line. There is complete atomization of the cooling water from zero to full load because the opening of the spray nozzle—not the pressure drop across it—is varied with steam temperature. A self-contained unit, as *dependable* as the COPES Feed Water Regulator. Write for Bulletin 405-A.

MASTER CONTROL...



Remote control of reduced water or steam pressures, with single or multiple pressure reducing stations, is *dependably* accurate with the COPES Master Control. Adapted for excess pressure control in boiler feeding, where one or more turbine-driven pumps discharge into a common water header. Details on request.

EDITORIAL

A Fundamental Approach

Many readers have undoubtedly received the survey blanks sent out by the U. S. Bureau of Labor Statistics dealing with the economic status of the engineer. This study was initiated and sponsored by the Engineers Joint Council, representing the five founder engineering societies, and the government bureau is merely handling the mechanics of the work for which it is especially equipped. About a hundred thousand members of the societies are thus being contacted and tabulation of the returns is expected to provide an excellent cross-section of what the various branches of the engineering profession have to offer in terms of opportunities, advancement and remuneration.

At a time when there is so much talk of collective bargaining for engineers, as evidenced by the discussion at the Boston Meeting of the A.S.M.E., this study by the Engineers Joint Council is most appropriate. It is a basic approach to the problem, the results of which should chart further action.

It is hoped that all who received the questionnaire will have filled it out promptly and returned it, so that the results may be forthcoming as early as possible.

Silica Turbine Deposits

The paper by Messrs. Warren and Howard, which is abstracted elsewhere in this issue, is an excellent and informative review of the methods currently employed by operators for the removal of deposits from steam-turbine blades, diaphragms and passages. The authors do not attempt to discuss means for the prevention of such deposits which is a matter that has received perhaps more attention during recent years than any other single subject in the field of steam generation. While marked progress has been made toward supplying turbines with relatively pure steam, through boiler-water treatment, steam washing and water separation, the problem does not yet appear to have been completely solved as long as silica enters the system.

It is not difficult to cope with the water-soluble deposits, mostly sodium salts, which form in the high-pressure stages; but the insoluble deposits, mainly silica, which are found in the low-pressure stages, present a real problem and usually necessitate mechanical removal with attendant outage of the machine.

In this connection a most pertinent report has just been published by the University of Illinois Engineering Experiment Station, as *Bulletin 364*, which gives the results of an investigation undertaken in cooperation with The Utilities Research Commission and under the direction of Prof. Frederick G. Straub. From this investigation it would appear that the insoluble silica deposit is the result of a volatile silica compound being formed at the higher steam pressures. Since silica as low as 0.2 ppm in the steam will cause depositions in the turbine, it is pointed out that this necessitates the maintenance of silica in the boiler water of high-pressure boilers in amounts to less than 10 ppm if turbine deposits are to be prevented.

Obviously, the best way to keep silica in the boiler water at a minimum is to keep it from entering the boiler; but this is not always possible. It then becomes necessary to precipitate it as an insoluble sludge within the boiler, and also to scrub the steam with pure water.

The report, among other things, details the investigation, discusses various treatments for reduction of the silica and shows how to test for silica. It marks another milestone in combating this troublesome problem and should be read by all concerned.

Prices vs. Production

Two weeks ago the Editor's personal mail contained a postcard announcing a ninety per cent discount on September residential electric bills by one of the New Jersey power companies, despite the regular rates being nominal.

While such action is not unusual in the electric utility field, still in these days of soaring prices on every hand, a notice of this character causes one to pause and reflect on the fact that, of all present-day necessities, electricity and gasoline (excluding taxes) have shown no increase over a long period, and in many instances have decreased in cost.

One may inquire as to how this has been possible in an age of steadily increasing fuel and labor costs. The answer is well known to engineers, but little appreciated by the general public. It involves a number of factors, including improved engineering design in both generation and application, competent operation, efficient management and increased use of electricity. Without these contributing factors utility regulating bodies would not have been justified in prescribing lowered rates in so many instances.

It remains to be seen, however, whether such conditions could be maintained if current rumors materialize as to further demands of the miners when the bituminous mines are turned back to the owners by the Government.

One fact stands out above all others—low rates and increased use of electricity are inseparable. It is a lesson that might well be applied to our present economic dilemma to prove that lower prices follow increased production.

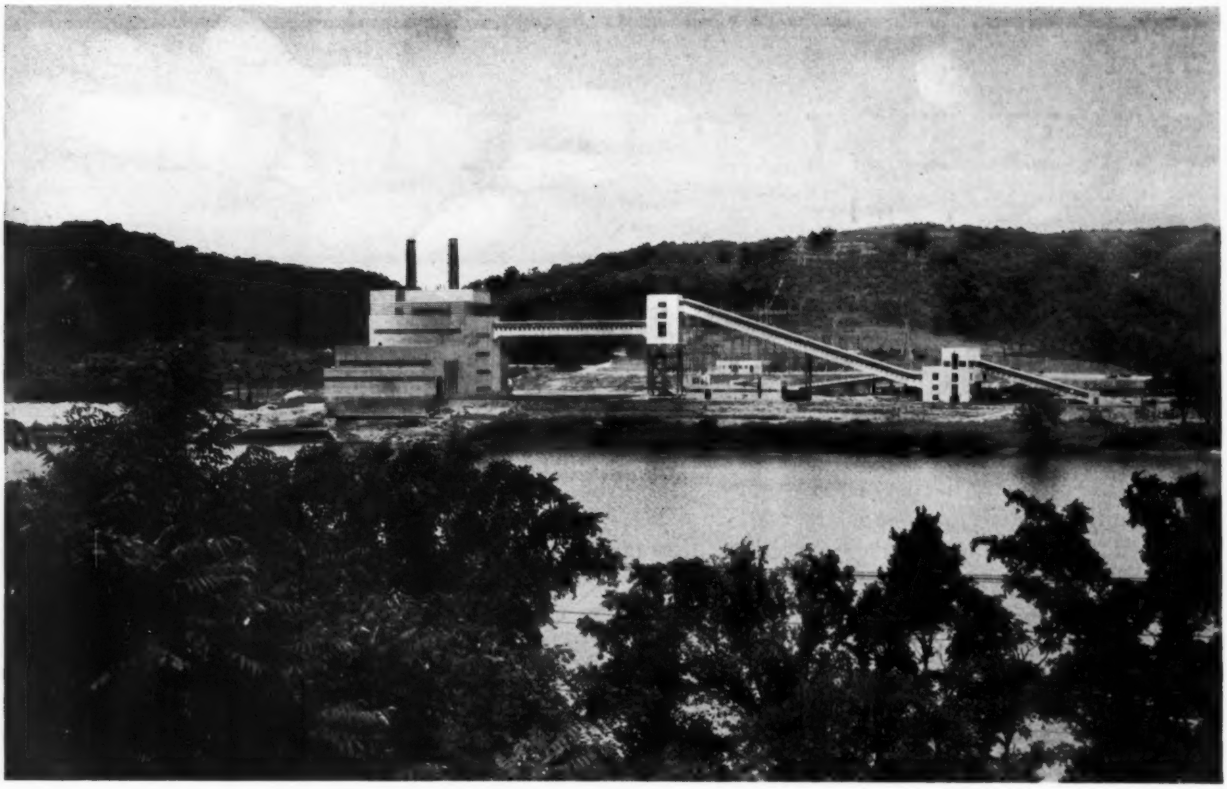


Fig. 1—General view of Tidd Station

Steam Generation at the New TIDD PLANT

By S. N. FIALA[1] and L. B. SCHUELER[2]

Two 475,000-lb per hr, tangentially fired steam-generating units supply steam at 1375 psig, 925 F to a 100,000-kw turbine-generator. Steam temperature is maintained within close limits by use of gas bypass dampers and spray-type desuperheaters, supplemented by vertically adjustable burners. Among the many unusual and novel features are electronic metering of flows and levels, remote control of pulverizer air-trip dampers, a continuous record of excess air, and a combined safety relief and emergency vent valve on the superheater outlet. The heat cycle adopted was aimed at securing best thermal performance.

THE initial installation of a 100,000-kw steam-electric generating unit in the new Tidd Plant, designed for The Ohio Power Company by the American Gas and Electric Service Corporation, was placed in commercial operation on September 26, 1945. The plant is located on the Ohio River at Brilliant, Ohio, south of Steubenville. Its output is delivered to the 132-kv and 66-kv transmission systems of The Ohio Power Company which is part of the regional power pool that is the Central System of the American Gas and Electric Company. The installation consists of a single-cylinder type, straight-condensing turbine-generator supplied with steam by two pulverized-fuel-fired boilers, each having a continuous capacity of 475,000 lb per hr. Full load steam conditions are 1375 psig and 925 F at the superheater outlet. Feedwater enters the economizer at 418 F.

The plant was begun during wartime, hence selection of equipment was restricted by the conditions then prevailing. A successful effort was made to conserve materials and to obtain the best possible realization of overall economy. This was done by concentrating attention to arrangement and the many details and refinements of operation. It is believed that the heat cycle adopted for this unit gives

[1] Mechanical Engineer, American Gas and Electric Service Corporation.
[2] Steam Generation Section Head, American Gas and Electric Service Corporation.

the best possible thermal performance under the conditions to be met.

Boiler, Furnace Walls and Superheater

The boiler units are designed for natural circulation and built for 1525 psig working pressure. Fig. 3 shows a sectional side elevation which indicates the general design, namely, a three-drum bent-tube boiler with a dry-bottom furnace for tangential pulverized-coal firing. Also indicated is the heat-recovery equipment, including the economizer and regenerative air preheater. Two ball-mill type of pulverizers are provided to serve each boiler.

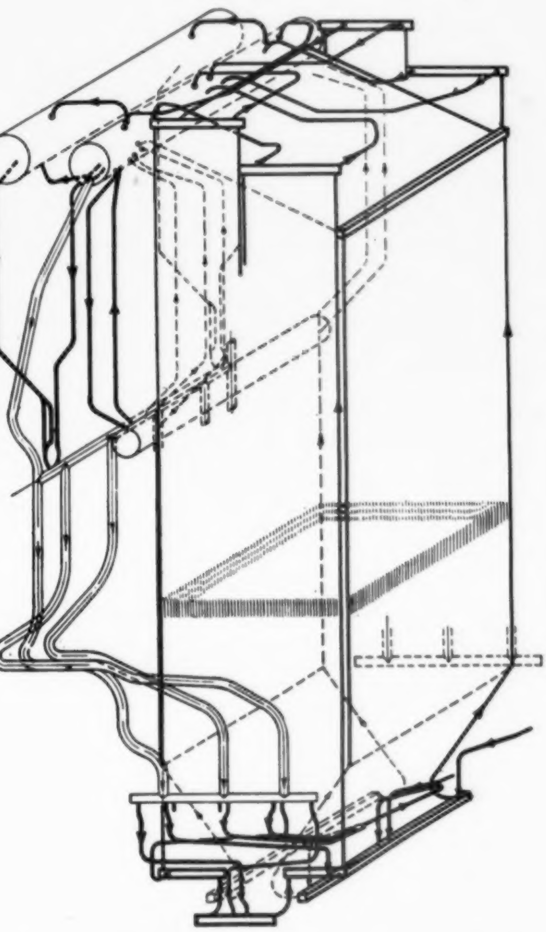


Fig. 2—Isometric outline of circulating system

All four furnace walls are made up of 3-in. OD bare tubes on $3^1/_8$-in. centers, each pair terminating in a $3^1/_2$-in. OD bifurcated header connection. The roof tubes are 3-in. OD fin tubes on $6^1/_4$-in. centers. All furnace-wall tubes and circulators are seal welded after rolling into headers and drums to assure tight joints of maximum strength.

The circulating system is augmented by the provision of outside downcomers to assure an adequate supply of solid water to all water-wall headers. An isometric outline of the furnace circulating system is shown in Fig. 2 which indicates the essential elements and flow pattern involved. Field circulation tests conducted on a boiler of this type at another plant on the American Gas and Electric Company system at Glen Lyn have shown an overall circulation ratio of 7 to 1 at maximum design output. An operating history of eight boiler-years with units of this particular design and identical operating characteristics has resulted in no failure of boiler or water-wall tubes due to overheating.

Superheater Design

Superheater design reflects the company's experience in the operation of many large, high-pressure and high-temperature boiler units. This experience dictated the wide spacing of the elements in the hot gas zone and closer spacing in the cooler gas zone to obviate difficulties due to slagging and permit maintaining high surface effectiveness with minimum hand lancing or mechanical cleaning. This is in accordance with the current trend in the industry. Means for superheat control are provided by a gas bypass damper around the primary superheater and a spray-type desuperheater between the primary and secondary superheater sections. The latter provision is the result of the operating experience on the American Gas and Electric Company system with many types of superheater steam-temperature-control arrangements. This will be covered more fully later.

Included in the soot-blowing system are furnace-wall blowing nozzles, retractable elements and rotary elements in the boiler and superheater sections and a single-nozzle mass blower for the air preheater. No blowers are provided for the economizer as experience on similar units has indicated them to be unnecessary. All blowers utilize high-pressure saturated steam from the boiler drum, reduced to 600-psi pressure by a reducing valve. They are air operated and control is of the remote automatic sequential type which permits a selective predetermined soot-blowing cycle to be carried out.

Fans

The forced- and induced-draft fans are designed to give best assurance of maximum availability of these important auxiliaries. Their construction is most substantial and features details of design which have proved outstandingly reliable on previous installations of high-duty units on this system. Each boiler has one 1180-rpm, constant-speed, motor-driven, forced-draft fan and two 880-rpm, constant-speed, motor-driven, induced-draft fans. Control is by means of inlet vanes with the forced-draft fan maintaining furnace draft and the induced-draft fans responding to combustion control requirements. An interesting feature in connection with the forced-draft-fan control involves the use of the inlet vanes and outlet louver dampers in series. The former are controlled to maintain a fixed pressure drop, about one inch of water, across the outlet damper, while the latter is controlled to maintain furnace draft. This arrangement produces good controllability and stable operation at reduced ratings.

An unusual arrangement of fan-room ventilation is employed. This functions as part of the plant air-conditioning system and involves special equipment and controls to avoid boiler unit operating difficulties. The exposed walls of the fan room have grilled openings with louvers for air control; and the forced-draft fans are set over an enclosure having louver dampers which are located directly above the boilers. In cold weather, plant heat is conserved by opening the fan-room wall louvers and closing the enclosure louvers so that com-

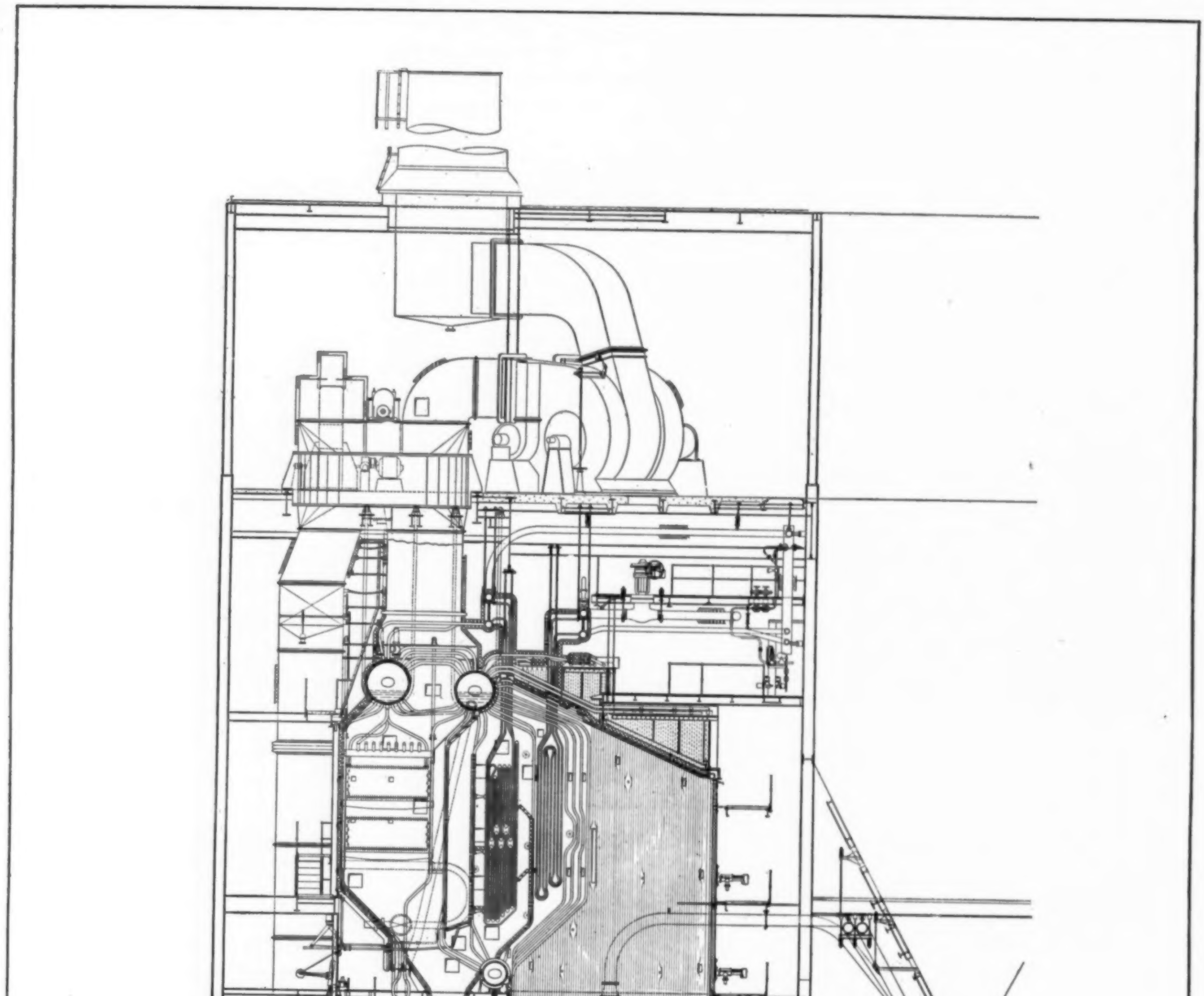


Fig. 3—Sectional elevation of steam-generating unit

bustion air is taken directly from outside. In warm weather this procedure is reversed so that excess plant heat is removed from above the boilers and utilized as combustion air. With this system the air heaters would be subject to plugging and corrosion when cold outside air is used; but to avoid this, recirculating fans are provided to return a portion of the hot air to the preheater inlet and temper the cold air. Automatic controls are employed to control the amount of recirculation in response to either low exit gas or low entering air temperature, whichever requires correction from set values.

Superheat Control

Means for superheat control are adequately provided by the gas bypass around the primary superheater and its control damper and by the spray desuperheater between the primary and secondary superheater sections. Both of these control elements function simultaneously and independently. The motorized bypass damper is controlled to maintain a predetermined steam temperature (835 F maximum) leaving the primary superheater, the maximum temperature being limited by the superheater material capability. Full automatic control and simple means for resetting control to desired level are provided.

The spray-type desuperheater is arranged to assure close control of the final steam temperature. In addition to providing rapid correction of temperature changes, this arrangement also provides means of prolonging the life of superheater elements by the thorough mixing and equalization of temperature of the partially superheated steam from the primary section.

The spray system is shown diagrammatically in Fig. 4 which indicates two sets of spray nozzles, each set being in series with a flow control valve. The two control valves are motorized and function automatically in response to steam temperature variation from pre-established value. For rise in steam temperature above that value the first control valve opens progressively until it is 50 per cent open. Further variation brings the second control valve into play and they both open progressively but with the second at twice the rate of the first, until both reach 100 per cent opening together. On closing, the process is reversed with No. 2 valve closing completely while No. 1 closes to 50 per cent and then No. 1 goes down alone to 0 per cent opening and flow. The entire system is fully automatic although the number of nozzles in service can be varied by opening or closing the hand valves in the line to each.

In addition to the above two superheat control elements, there is another substantial increment of superheat control provided by the vertical tilting of the burner coal and air nozzles. This could have been made a control element by providing motorized actuators automatically controlled by steam temperature. However, the burner tilting is employed as an auxiliary measure in the superheat control program particularly during periods of abnormal operation such as (1) very low load, (2) feedwater heaters out of service, (3) abnormal furnace cleanliness, (4) poor feedwater quality for spray desuperheater, (5) periods when bypass damper and/or desuperheater are out of service.

The several superheat control and adjustment elements play a useful and important role in providing means for varying steam temperature of one boiler or the other while bringing them in or out of service. In this case it is important to minimize steam temperature variation in the steam leads from each boiler and rapid fluctuation in steam temperature to the turbine. For example, with one boiler operating at full load and 925 F steam temperature and the second boiler being brought into service, the procedure followed is to gradually drop the first boiler steam outlet temperature to about 825 F (which can ordinarily be done without any load reduction) and bring the second boiler on at about 750 F. The second boiler is rapidly loaded to get up to 825 F and then the temperature for both is gradually raised to normal of 925 F. In this way no output has been sacrificed and the second boiler is brought into service and up to load rapidly and without severe temperature stresses being produced in the steam lead branch from each boiler and in the turbine shell. The procedure is followed in reverse order for taking one boiler out of service.

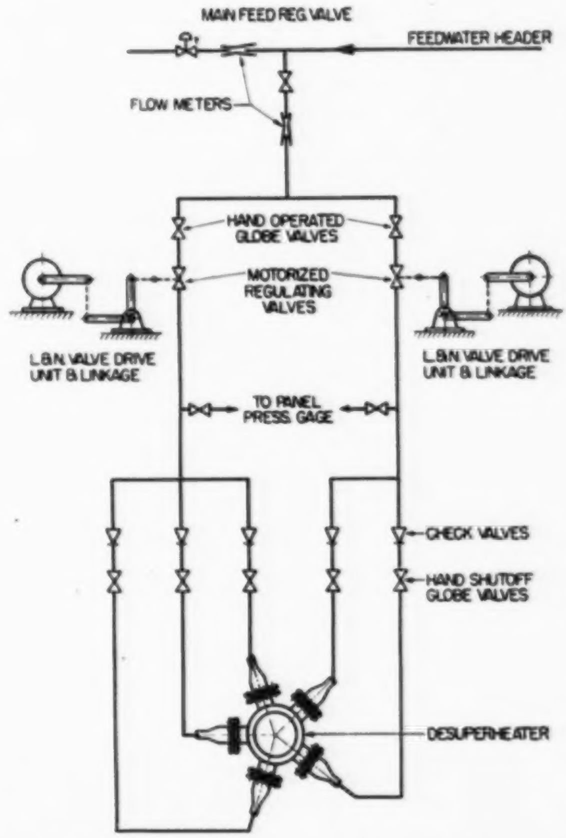


Fig. 4—Layout of spray system for superheat control

Boiler Controls and Control Room

All controls and remote operative devices for the boilers, turbine, generator, heat cycle, pumps, and electrical switching are centralized in a single control room located on the main operating floor in the space between the boilers and the turbine. This design features optimum convenience to coördinated operation of the unit from raw coal feed to generator output.

The combustion controls are of the all-electric type and function through a steam-pressure regulator connected to the steam pipe at the inlet to the turbine stop valve.

This regulator varies the loading voltage on the solenoids of the draft fan and the fuel-control regulators. The loading voltage is mathematically related to balancing forces of control regulators, which relationship serves to maintain proper proportioning of fuel and air input.

To improve the accuracy and sensitivity of regulators a vacuum tube circuit was adopted to provide amplification of the primary contacts and thus give positive operation of motor-driven actuators for the slightest deviation from control standard. The use of vacuum tubes permits the primary contacts to be very sensitive as these handle only the grid current of the tubes. All regulators are equipped with remote-reading electrical position indicators.

The temperature of the coal-air mixture delivered by each pulverizer is automatically controlled by an air-operated regulator which positions the cold-air tempering damper. This air is delivered under pressure by tempering air fans.

Feedwater control is of the three-element type. The high-pressure piping to the steam-flow, water-flow and drum-level recorders and indicators in the control room has been eliminated by the use of electronic telemeters. As shown in Fig. 6, the measuring units are located close to the high-pressure piping. They operate electronic transmitters of the impedance-bridge type, connected to the receiving units of the recorders in the control room.

In order to give a direct and prompt indication of excess air, a recording oxygen meter is employed. This device has an inherently small time lag and, therefore, indicates rapidly the result of variations of air and fuel introduced to the furnace. The device employs the principle of catalytic combustion. The gas sample is drawn continuously at a very rapid rate and a portion is skimmed off for analysis in the instrument. This is accomplished by mixing the sample with a standardized liquid fuel and then catalytically burning it by means of a platinum filament. The quantity of standardized fuel burned is proportional to the quantity of oxygen content in the gas sample. The temperature rise resultant from the burning of a given quantity of the standardized fuel is measured by determining the resistance of platinum filament. The resistance of the filament and, accordingly, the oxygen content, is determined by means of an alternating-current self-balancing Wheatstone bridge. In order to obtain sensitivity and accuracy, the bridge and balance are amplified by electronic tubes, thus giving for each minute variation a positive actuating electrical impulse necessary to position the balancing and recording device. The variations in oxygen are expressed on the recording chart in terms of per cent excess air.

Coal and Ash Handling

Coal-handling facilities have been sized to meet future plant expansion requirements, and the equipment installed is capable of handling, storing and delivery to bunkers at the rate of 800 tons per hour. Facilities include provision for coal delivery by rail and truck, and the layout is such that unloading from river barges can be readily provided. Coal is unloaded from railroad cars with a rotary dumper and picked up by a conveyor belt which delivers it to the storage area or to the conveyor system and to the plant bunkers. The auxiliary equipment includes two ring crushers, vibrating screen and a magnetic pulley for sizing and cleaning coal prior to delivery to the bunkers. There is also an automatic coal sampler and crusher installed along the conveyor system which samples coal continuously for fuel purchasing purposes and plant heat-balance determinations. Handling of coal into and out of storage is by bulldozer when the distance is short and by carryall from greater distance. The initial storage area is capable of receiving up to approximately 175,000 tons of coal. Railroad cars are handled by a plant fireless locomotive that is charged periodically with saturated steam from the main power boilers, reduced to 600 psi and piped to a convenient charging station in the yard. The coal is discharged into the bunker by a tripper operating along the conveyor belt in the plant. The tripper has rubber sealing strips to continuously seal the conveyor room from dust in the bunker. In addition, the conveyor room is provided with positive ventilation by a separate blower and duct system in which air is heated by unit heaters and delivered throughout the room and then vented down the incoming conveyor shaft.

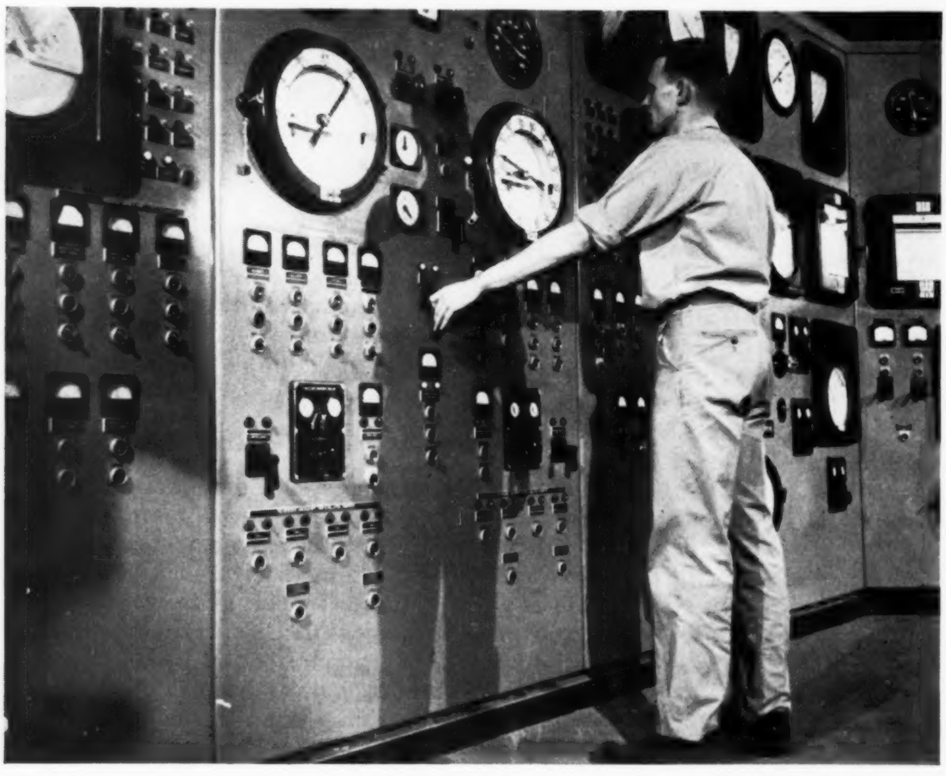


Fig. 5—Control board

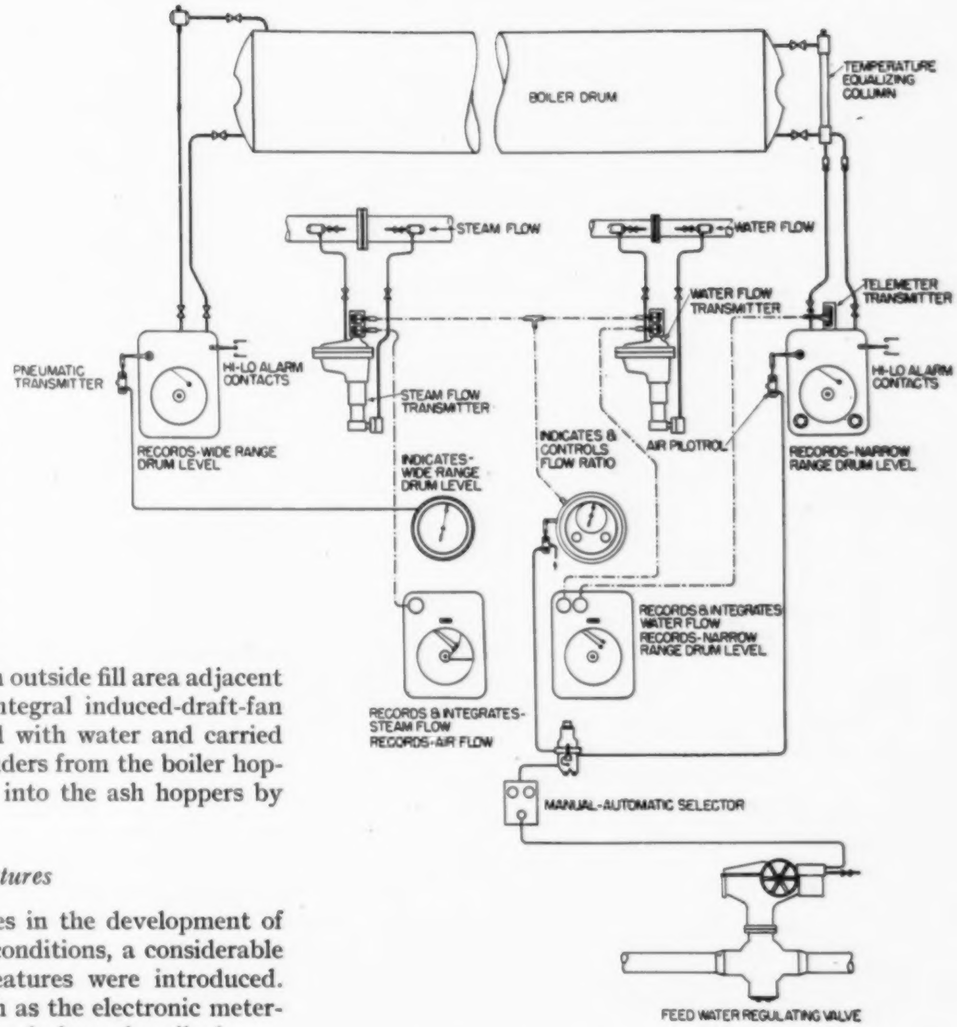


Fig. 6—Diagrammatic layout of drum-level control

The boiler ash hoppers are operated "wet", that is, a water level is maintained in the hopper at all times to chill falling clinkers and prevent formation of clinkers and reduce refractory maintenance. Ashes are sluiced periodically to an ash pit between, and common to, both boilers and are pumped out intermittently by a conventional ash-pumping system to an outside fill area adjacent to the plant. Fly ash from integral induced-draft-fan collectors is immediately mixed with water and carried to the fill area by gravity. Cinders from the boiler hoppers are water-mixed and flow into the ash hoppers by gravity.

Special Features

In the face of many obstacles in the development of new ideas because of wartime conditions, a considerable number of special or novel features were introduced. Some of the developments, such as the electronic metering of flows and levels, have already been described.

One of the special features is the remote control for the pulverizer air-trip dampers. The standard arrangement of ball-mill pulverizers requires local hand operation of the exhauster inlet air-trip dampers. To provide operation of these dampers from the control room a new motor-operated trip and relatching system was developed. The motorized operation of the dampers is such that mechanical linkage controlled by push-button operation from the main control panel will open the dampers to operating position either for normal starting or after any abnormal condition causing the dampers to close. This feature permits the operator in the main control room to place pulverized-coal equipment in service without any assistance at the pulverizing equipment stations. Its advantages are particularly important in permitting much quicker restoration of this equipment to service after emergency outages which generally tax the available manpower severely. The apparatus fulfills all automatic protection functions and provides remote trip and relatching facilities for control room operator.

Another novel feature is the combined safety relief and emergency vent valve located at the superheater outlet. This consists of a motor-operated globe valve of special design for throttling service with high-temperature steam. Valve motor controls are such that automatic over-pressure relief is obtained by a pressure switch contact to open, and automatic closing at somewhat lower pressure (about 1 per cent) is instituted by a second pressure switch. The motor is designed for high-speed operation. As a safety relief valve it is capable of passing 80,000 lb steam per hour at design pressure and temperature. In addition, the valve can be used as an emergency superheater outlet vent valve by remote manual operation from the central control room. Position indicators at the panel show the position of the valve movement. With this equipment the superheater can be vented with greater degree of safety, economy, and convenience.

Each boiler feedwater-regulating station is equipped with a special remotely operated flow-control valve designed for starting-up service requirement of very low flow at full boiler feed pump differential pressure. This feature is in addition to the motorized bypass valve around the feedwater-level regulating valve.

Excessive boiler-drum water level can be remedied promptly from the central control room by remote operation of a blowdown valve connected to the steam drum at a point slightly above normal operating level.

The foregoing are some examples of the philosophy employed in obtaining a balanced arrangement necessary to best overall economy of power production.

The project was carried out under the direction of Mr. Philip Sporn, Executive Vice President and Chief Engineer. The plant was named after Mr. George N. Tidd, President of the Company and pioneer in the electric power industry.

Insulation in the Design of Steam Generating Units

By DR. M. J. FISH

Combustion Engineering Co., Inc.

A review of current practice in the insulation of boiler walls, furnace walls, ducts, drums, headers, etc., together with a discussion of the composition and application of the materials involved.

THE role which refractory and insulating materials play in the successful design and operation of steam-generating units is extremely important. These materials make possible the economic production of steam as well as aid in the efficacy of operation and durability of the unit. The present article will attempt a brief description of the usual materials and their application.

Early experience with pulverized coal firing showed that solid refractory firebrick furnace walls could not withstand the temperatures to which they were subjected. This knowledge led to the development of waterwalls in which the furnaces of large units are lined with closely spaced tubes which are part of the circulation system of

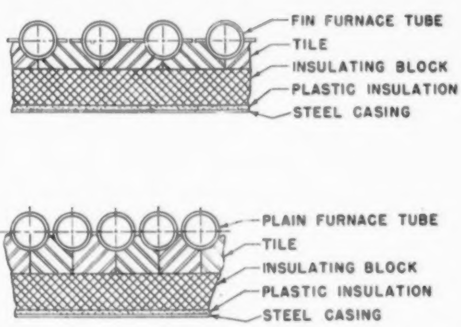


Fig. 1—Typical construction of furnace wall with pulverized coal

the unit. When fins are welded to the tubes the latter can be spaced farther apart, since the fins absorb a portion of the heat and transmit it to the fluid within the tubes.

Directly in back of the tubes, and supported on them, are specially shaped tiles made from high quality fireclays. When this tile is furnished in two layers the joints are staggered to reduce furnace gas leakage. In back of this refractory tile is a layer of insulating blocks of sufficient thickness to reduce the outside wall temperature to a reasonable value. These blocks are supported on the outer steel casing which is kept in place by means of structural steel members. However, a thin space, to be filled with a plastic insulating cement, is provided between the insulating block and the casing. Fig. 1 illustrates this construction.

Although this cement has insulating qualities, its purpose here is as a filler. It prevents the infiltration of air from the boiler room into the furnace, and prevents the furnace gases from passing between zones of different pressure in back of the tubes. The plastic cement insulations used for this purpose are furnished in powder form, and when mixed with water, they form an adhesive mixture which becomes dry within a reasonable time.

Boiler Setting Walls

Boiler setting walls, which vary in construction, are never exposed to the extreme temperatures which furnace walls must withstand. The boiler sidewalls continue from the point where the furnace sidewalls stop. The furnace sidewall tubes extend to the entrance of the boiler zone, at which point, the highest gas temperatures of this zone exist.

From a historic standpoint, the oldest type of wall for the boiler zone is of solid firebrick which varies from $13^1/_2$ in. to $22^1/_2$ in. in thickness. The variation in thickness depends upon the temperature which it encloses and the height of the wall. Due to the heavy steel which is necessary to support such large weights, modern walls use lighter materials. A construction ordinarily used in the boiler sidewall of large steam generators consists of a layer of high quality firebrick whose thickness seldom exceeds 9 in. Behind this is a layer of suitable insulating brick, a filler coat of plastic insulation, and an outer steel casing. Fig. 2 is representative.

There are various forms of self-supporting walls which consist of specially shaped refractory tiles supported by castings. The latter are suspended from the structural-steel supporting system. The tile and castings are arranged to form a vertical sequence of horizontal belts 2 to 3 ft high with allowance for expansion. Often, plastic insulation or insulating block is placed behind the tile shapes and the whole enclosed in a steel casing. Other

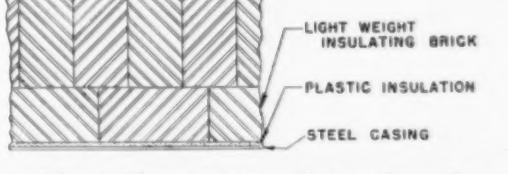


Fig. 2—Representative boiler side wall

constructions permit circulation of air for cooling by providing space between the tile and the insulation.

Because the rear wall of a boiler setting is exposed to the minimum temperatures within the steam generating unit, its insulation requirements are much less than those of other walls. Although such walls have been built of solid refractory brick with thicknesses from $13^1/_2$ in. to 18 in., modern construction furnishes a wall with less weight. A rear boiler wall may consist of a layer of flat refractory tile which does not exceed 4 in. in thickness. Behind this is a layer of insulating block of sufficient thickness, a plastic insulation filler, all enclosed in an outer steel casing.

Composition of Refractory Tile and Firebrick

Selection of the proper refractory and insulating materials in the various parts of a steam-generating unit requires a knowledge of the chemical composition and physical limitations of the materials. For instance, refractory tile and standard firebrick shapes are made from a blend of several qualities of fireclay together with ground firebrick, or saggers. The latter are of known quality and have no slag adherence. The quality of the finished product is determined by its resistance to high temperature, ability to withstand sudden changes of temperature, and imperviousness to the chemical action of the fuel and slag which it encounters in the furnace operation.

High-quality firebrick is obtained by the careful blending of fireclays with large percentages of alumina and silica. The fireclay deposits should be reasonably free from impurities. The mixture of blended raw clays and ground grog are brought to an even mixture in the pug mill and the final shapes are heated slowly and evenly in the kiln. The essential ingredients of fireclay are hydrated aluminum silicates. When the water is driven off at a high temperature, the resulting fireclay material consists of about 45 per cent alumina (AL_2O_3) and 55 per cent silica (SiO_2). Even the purest clays contain small amounts of other compounds such as calcium, magnesium, potassium, sodium and titanium.

Insulating Blocks

Another material which has been mentioned is known as insulating block. Although the blocks put out by various manufacturers, differ, they are all made by mixing together materials of high insulating value. Usually, these materials are diatomaceous silica, mineral or slag wool, and asbestos fibers. A suitable binder such as bentonite clay is put into the mixture. Either a slurry of these materials is poured into forms or the materials are pressed into block shape while wet and then dried in a furnace whose temperature is a bit higher than that of boiling water. One important difference between these blocks and insulating firebrick is that the blocks have not been subjected to temperatures high enough to cause chemical bond. The blocks should not be used in temperature zones which will effect this chemical change.

The commercial insulating block is cut to standard sizes of 3 ft long by 6 in. and 12 in. wide with thicknesses up to 4 in. Some blocks will withstand temperatures in the neighborhood of 1200 F. Organic compounds which will deteriorate at lower temperatures should not be among the ingredients of these blocks. Insulating blocks which are to be used for lower maximum temperatures are made from a mixture of materials suitable to those temperatures. One of these is known as 85 per cent Magnesia. It is composed of hydrated magnesium carbonate with asbestos fiber, all molded and pressed into shape. Its use is limited to temperatures under 600 F because at a slightly higher temperature, the magnesia will decompose into carbon dioxide gas and a magnesium oxide powder. It is important that insulating blocks be of sufficient strength to be handled and shipped without breakage or excessive dusting. During the erection of a steam generating unit, it is necessary to cut many of the standard size blocks into special shapes. A good block will not be too brittle or friable for this procedure.

One product which is capable of being a good insulator at elevated temperatures is known as insulating firebrick. It is a porous substance made by mixing a finely granulated volatile organic material, such as napthalene, together with the plastic clay mixture that is used to manufacture the ordinary solid firebrick. When the resulting mixture is baked in the kiln, the organic chemical volatilizes so that the final brick is porous and full of voids. Other combustible materials such as cork and sawdust instead of naphthalene may be mixed with the clay to obtain these light-weight insulating bricks. Cork is used more extensively than is sawdust because moisture does not adhere to the cork as readily and a more uniform product is obtained. The combustible matter is burned out in the kiln. When the brick has cooled, it must be machined to accurate dimensions since the volatile products of combustion have caused the fireclay to attenuate and the brick to increase in volume. Since these bricks are more susceptible to breakage and dusting than are refractory firebrick, it is usual to safeguard them in shipment. They are packed in reinforced cartons with partitions to separate each brick.

Rockwool Insulation

An extremely interesting insulator is one that is commonly called "rockwool." It is usual for the manufacturer of this product to locate his plant near a source of slag. The slag is more uniform in silica content than is rock. The ingredients for the wool are about 40 per cent limestone, 40 per cent slag and the remainder is coke. These raw materials are fed continuously into a cupola which is almost a duplicate of a large iron cupola. Air for combustion is supplied at fairly large pressures. The molten mass settles to the bottom of the combustion space from which it flows in a small continuous stream. A horizontal steam jet is directed against the stream which is blown into a large settling chamber and the molten mass is blown into innumerable threads of extremely small diameter. The cooling action of the atmosphere in the settling chamber terminates this thinning action.

If the material in the individual thread is not wholly thinned, there will be a small tail or accumulation at one end of the thread. When these tails break off during subsequent handling, they are called "shot." Too much shot will reduce the insulating value of the mineral wool. The wool is made up into blankets and bats on a felting machine. Better control of the whole process and development of the steam nozzles have brought about a reduction of shot. The density of mineral wool has been decreased from about 14 lb per cu ft to 8 lb per cu ft.

The loose wool has a variety of uses. For insulation of homes, it is formed into bats, is granulated or left loose. It is combined with diatomaceous earth to make a fibrous packing insulation for filling irregular spaces. It is used in the manufacture of monolithic insulating cements and in insulating blocks.

Asbestos Products

Asbestos is the name given to a group of minerals which possess a crystalline fibrous structure and can be spun or felted. The minerals are silicates of lime, magnesia or iron with various amounts of impurities. Canada leads in the size of the deposits and South Africa is second. The mineral called chrysotile which is an anhydrous silicate of magnesia furnishes most of the commercial asbestos. It occurs in narrow veins as a mass of fine silky crystals. No doubt, the crystalline form is due to the rate of cooling of the hot siliceous waters during the prehistoric changes of the earth's crust.

The crystals are separated into fine, silky, flexible fibers. Choice deposits have long, fine fibers which are tough, flexible and have relatively high tensile strength. The incombustible and insulating properties of asbestos make it invaluable to industry. When impregnated with rubber, asbestos is used for gaskets. Asbestos yarns are impregnated with graphite to be used for steam and pump packing. Certain classes of short asbestos fiber are mixed with portland cement and molded into pipes and other shapes. This same mixture is pressed into shingles and wallboard. Asbestos sheets deaden sound and asbestos papers are used where damp-proof and waterproof coverings are needed.

Cements are too numerous to be detailed in this article. The refractory cements use calcined materials as a base together with a suitable binder. These cements withstand high temperatures when used to bond refractory firebrick. Plastic insulating cements can be made from mineral wool, diatomaceous earth and other ingredients. When the insulating cement is used as a finishing coat, it should have the property that it does not shrink as the moisture evaporates. If the expansion is volumetric, the possibility of developing cracks is lessened. When portland cement is mixed with plastic insulation, the result will give an adhering mixture which can be trowelled to a smooth, even surface.

Insulation of Ducts

When ducts convey hot air or furnace gases whose temperature is not excessive, mineral slag, rockwool blankets or block insulation can be used effectively. In the case of the block insulation, a harder surface is presented as a base for the outer cement. Since this insulation is less resilient to trowelling pressure than is the blanket insulation, a smoother outer cement finish is often obtained with the block.

One successful method of fastening mineral-wool blankets to the duct is as follows: Wires, $^3/_{16}$-in. diameter, are spot-welded to the outside of the duct metal on adequately spaced intervals. These wires are used for impaling the blanket and protruding through a metal lath which rests against the outer side of the blanket. These impaling wires are bent against the blanket and lath ensemble to act as fasteners for the lath. The latter supports the layers of cement which is applied in two coats. The inner cement coat is adjacent to and held on by the metal lath while a layer of poultry wire is wrapped around the inner cement coat as a reinforcing mesh for supporting the outer or finish coat of cement. Fig. 3 shows a typical duct insulation.

The flanges and the stiffening angles of the ductwork should be covered with a thickness of insulation which is equivalent to that on the remaining portion of the duct. At one installation, the beams which reinforce the duct were only partially covered by the insulation. The difference in temperature between the part of the beams touching the duct and the portion exposed to the atmosphere caused considerable bowing of these beams. Later, the beams were completely covered by insulation, the heat flow was no longer uneven, and the bowing disappeared. Covering of the flanges also avoids spotty burn marks on the outer cement due to concentrated heat flow.

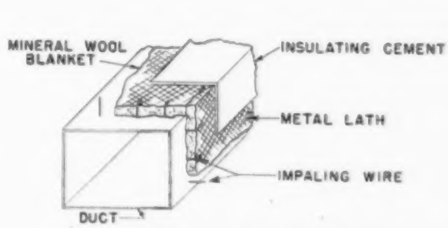


Fig. 3—Exterior duct insulation

When the temperatures of the gases within the ducts are excessive, it is advisable to line the inside of the duct rather than the outside. Such temperatures may occur in the ducts which convey the combustion gases from the last pass of the steam-generating unit to the stack. An inside lining will preserve the duct metal which would deteriorate rapidly if left exposed to the high heat and to the abrasive action of the flyash. Another instance of the use of this inner duct lining is in outdoor power plant installations where the duct is exposed to atmospheric conditions. Although there are excellent asphaltic compounds that can be used as a protective cover for exposed insulation, some plant operators prefer to have the duct with an inside lining. Commonly, the lining which is used is the block type of insulation.

To keep the block in place, adjacent to the duct metal, studs are welded to the inside duct metal on convenient centers. These studs are long enough to extend through the block. Metal wire lacing is inserted in holes situated at the free end of the welded stud. This lacing keeps the insulation block in place somewhat in the nature of the ordinary cotter pin.

For gas ducts in general, insulating block installed on inside surfaces must be protected against abrasion. To accomplish this, expanded metal lath is placed next to the block. This metal supports a one-inch thickness of a hydraulic setting refractory cement. This cement should be trowelled to a smooth and even surface so that it will not furnish too much resistance to the gas flow. The cement, which will afford a protection to the block, is easy to repair.

If the temperature of the gas within the duct exceeds 900 F it is recommended that the inside or exposed surface of the insulating block be protected by an 18- or 20-gage alloy plate. If the refractory cement were to be

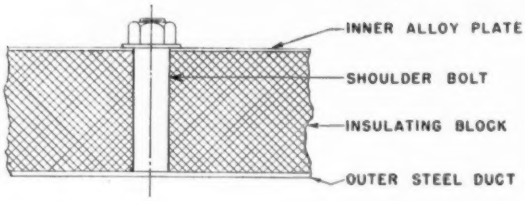


Fig. 4—Method of attaching inside duct insulation

used at such elevated temperature, and portions of it were to crack or fall off, the deteriorating action of the gases could be rapid. The oxygen which is present in the gases would react with the metal lath and with the duct itself if cracks developed in the inner insulating block. The use of the alloy covering plate prevents this possibility. The plates can be held in place by means of shoulder bolts with nuts and washers as shown in Fig. 4.

The expansion joints of both the gas and hot-air ducts are usually covered with mineral wool blankets of sufficient thickness to take care of the temperature differential between the inside of the duct and the surrounding or ambient air. The mineral-wool blanket is formed to assume the shape of the joint. To furnish an exterior protection for the mineral-wool blanket, a fiberglass cloth may be fitted snugly over the mineral wool and fastened to the ducts at each side of the expansion joint. In instances where dust may accumulate inside the expansion joints, a metal plate is provided as a sliding seal across the joint opening while the space within the plate and joint is filled with loose mineral wool. The seal plate retains the mineral wool and it prevents the infiltration of dust into the spaces of the expansion joint. Fig. 5 shows the insulation of a typical joint.

Slagging Bottom Furnaces

In a slagging-bottom type of furnace the bottom of the furnace is made of steel plate supported by structural-steel members. Resting directly on the steel plate is insulating firebrick. On top of this is a layer of refractory firebrick over which is spread a thickness of hydraulic setting refractory cement in which the bottom furnace tubes are imbedded. On top of the tubes is a layer of plastic chrome ore. This chrome refractory is extremely heavy, weighing about 200 lb per cu ft. Since this density is greater than that of the molten slag, the latter will stay on top of the chrome ore and discharge continuously from the spout. The insulating firebrick beneath the plastic chrome retains enough heat in the furnace to keep the slag in a molten state. Fig. 6 shows such an arrangement.

Insulation of Drums, Superheater Headers and Risers

When the cylindrical portions of boiler drums do not have a steel casing covering, it is usual to provide them with a suitable thickness of block-type insulation. The block is covered with expanded metal or poultry mesh wire and then given a coat of hard-finish cement. Drum heads are equipped with manholes for access to the inside of the drum. The heads are insulated with block

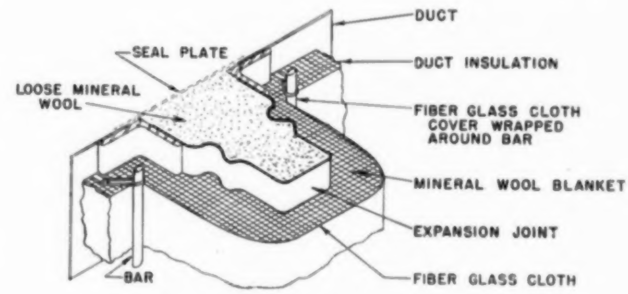


Fig. 5—Typical joint insulation

insulation as described above. A ring fabricated of steel plate encloses the manhole to protect the insulation against damage when the manhole is opened.

Similarly, superheater headers do not have any insulation on them when they are enclosed in a steel casing. Otherwise, the exposed surface of the headers is covered by a layer of high-temperature block adjacent to the header. On top of this is a layer of magnesia block followed by a hard finish cement, $^1/_2$ in. thick. The whole insulation assembly is then covered with 8-oz canvas. Fig. 7 shows a typical superheater header treated in this manner.

Steam risers and water downtake tubes must be insulated. When the tubes are covered singly, an insulating block which is furnished to fit the cylindrical shape of the tube is used. If the tubes or pipes are close together, they are enclosed in mineral-wool blankets or in insulating blocks and covered with a finishing cement. A canvas duck cover is placed on the outside and encloses the whole. In the case of the individual tube, the finishing cement is not needed since the canvas can be wrapped

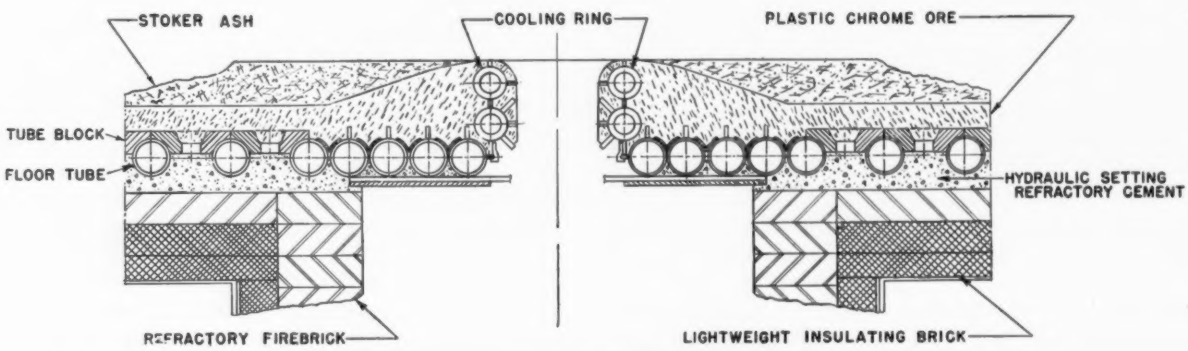


Fig. 6—Insulation on slagging bottom furnace

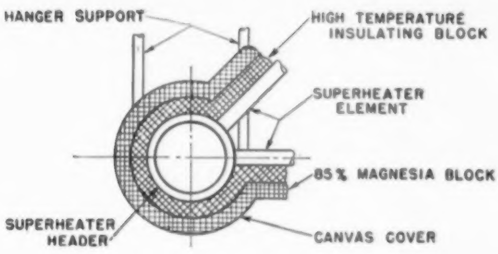


Fig. 7—Insulation of superheater header

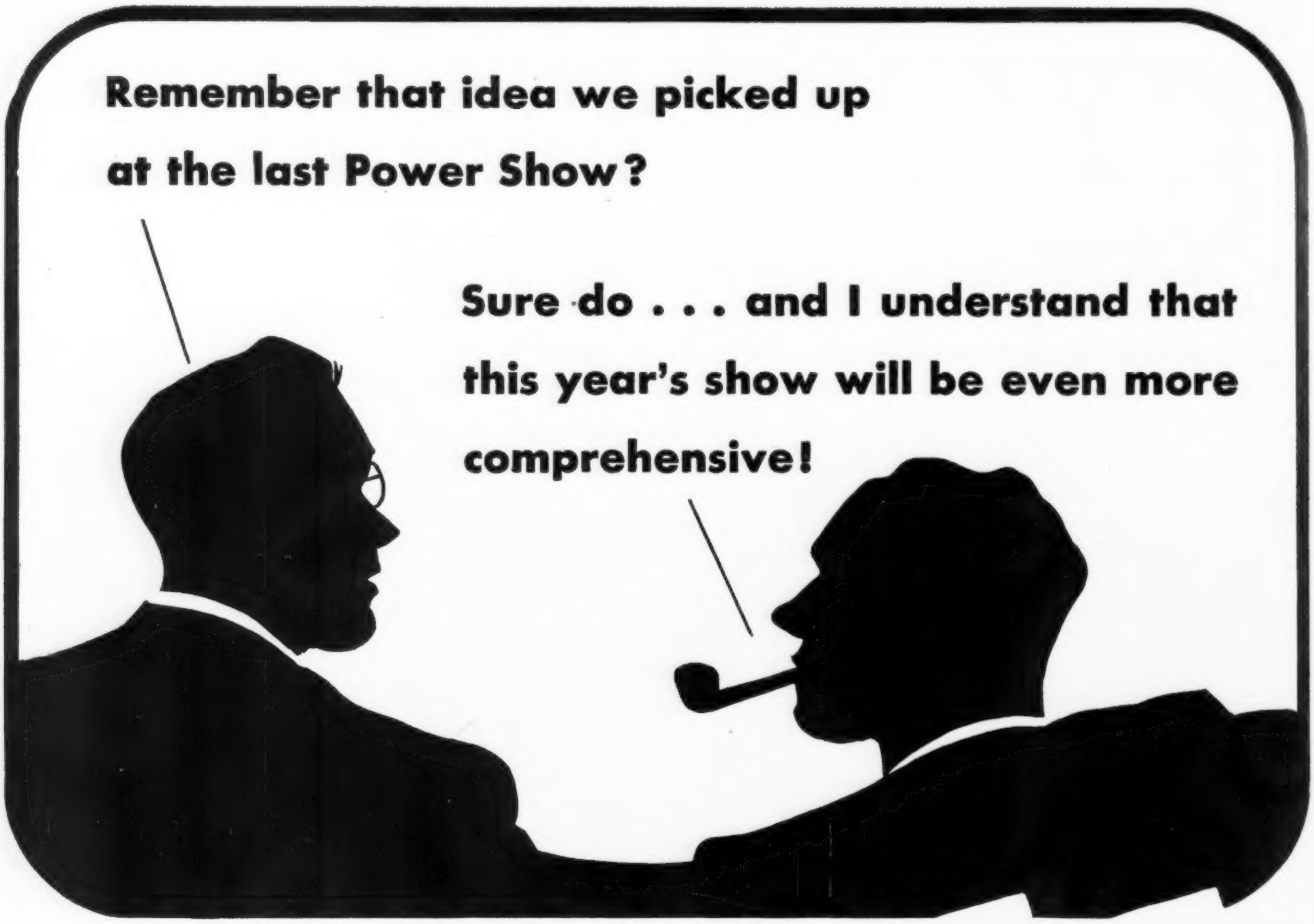
directly over rosin paper which has been placed around the block insulation of the tube.

When insulating, a distinction is made between ash and soot hoppers. The ash hopper is subjected to higher temperatures than is the soot hopper, since the former is located underneath the furnace proper while the latter is at some rear pass location of the unit. These hoppers are made of steel plate which is fastened to and supported by structural steel. Naturally, the steel must be protected against the heat, as well as against the abrasive and corrosive action of the ash and soot. For an ash hopper, a layer of insulating firebrick adjacent to the inside of the hopper plate is covered with a 2-in. layer of flat refractory tile. Since the hopper has sloping sides, it is necessary to hold this material in place, by metal studs welded to the inside of the plate and long enough to protrude through the thicknesses of insulating brick and tile. These studs are spaced at frequent intervals and are so arranged that a stud is located at insulating brick and tile corners. A metal washer holds the assembly in position. When the temperature is high enough to justify its use, a washer of alloy material is used.

In soot hoppers, the insulating material can be of block instead of light-weight brick. Since the composition of the latter is calcined refractory fireclay, it is able to resist the thermal action of the fuel ash if there is a slight opening in the upper layer of tile. Sometimes the temperatures are low enough so that the use of insulation is avoided and refractory firebrick only is used for the hopper lining. This brick is fastened to the hopper with metal studs as described above.

Factors in Selection of Insulation

It may be repeated that the selection of insulation for a modern steam-generating unit calls for a knowledge of ceramics and chemistry as well as sound judgment. An adequate quantity of the correct material must be selected. Economies of heat flow from the surfaces of the unit must be balanced against the cost of insulation, the cost of installation or application and the durability of the material. Often, it is more economical to choose an insulating material which will give longer service than a more fragile one that has a slightly lower conductivity. Although plant maintenance is not within the province of the equipment manufacturer, too much emphasis cannot be placed upon the upkeep and renewal of the insulation in a power plant. When bare surfaces are patched up, substantial financial savings can be effected with the present high price of fuel.



IDEAS? There'll be plenty of them in nearly 400 exhibits at the 1946 Power Show. Production ideas... maintenance ideas... *money-saving* ideas. Come and see what the nation's leading suppliers of power equipment are doing and thinking about. Talk to specialists at the informative exhibits.

The Power Show is for *power men.* General public not admitted. Admission by registration. Reserve the date. Be there with your associates.

17th NATIONAL POWER SHOW

GRAND CENTRAL PALACE, NEW YORK • DEC. 2-7, 1946

*Removal of Deposits from Steam-Turbine Steam Passages**

By G. B. WARREN[1] and T. W. HOWARD[2]

A review of the existing operating procedures for removing both soluble and insoluble deposits. With each of these the authors recommend certain precautions in order to avoid accompanying hazards.

DEPOSITS in those sections of a turbine operating well above the dew-point temperature are usually water-soluble. Deposits in those sections subjected for the most part to saturated steam are usually water-insoluble.

Hazards associated with the formation of deposits are sometimes not fully understood. Often operators are governed entirely by loss in unit capacity and when that becomes great enough to make action necessary, corrective steps are taken. This criterion may be safely used only when the deposit formations are uniform throughout all stages of the turbine and are about of equal magnitude on the rotating and stationary elements. Perhaps the most common situation is for the deposits to collect in some particular location within the turbine. Such deposits have a marked detrimental effect on turbine efficiency as well as capacity. Extensive nonuniform plugging can result in thrust failure, wheel rubbing and other serious troubles.

Detecting Deposits

To detect turbine deposits certain definite practices should become a standard procedure whenever a turbine is put in operation, and they should be continued throughout the operating life of the unit, such as:

(*a*) Read and record all available stage pressures, with corresponding throttle flow, inlet temperatures and pressure, exhaust pressure, feedwater temperatures; and make notations as to the feed-heaters in operation and load on the unit. These readings should be compared with design data (either from the instruction book or from the contract, or from special curves) and, if in doubt, submitted to the manufacturer's engineers for comment. Include also data on thrust-bearing oil temperature in and out.

(*b*) Make it a regular practice to compare these first readings with those taken as time goes on, at least from week to week. It is important that these readings be taken under comparable conditions.

It is, of course, possible for the internal parts of a new turbine to be damaged, due, for example, to weld beads or some other foreign material having been carried over from the boiler, superheater or incoming pipe lines. Such damage may cause high-stage-pressure indications similar to those due to deposits, but in the absence of vibration, rubbing or other evidences of distress and with a gradual increase in stage pressures, it is customary first to suspect deposits and to attempt their removal. If washing fails to make any change in the abnormally high pressures in the region of the soluble deposits, then mechanical damage may be suspected.

Washing

For normal variable-load operation much greater rates of temperature change are permissible than can be approved in a washing procedure. The following is probably a safe rule to use: For all washing procedures applied to turbines of 10,000-kw rating and above, the temperatures should not be reduced faster than 25 deg F in any fifteen minutes or 100 deg F in an hour. For units in sizes up to 10,000 kw, the rate of change may be increased inversely as the size of the unit up to a maximum change of 50 deg F in fifteen minutes or 200 deg F in an hour for the smaller ratings.

Washing apparatus should be as reliable and instruments should be provided to indicate the progress of a wash as completely as is the case with usual plant-operating equipment. Very often washing equipment is of a temporary character, perhaps with the hope it will be used but once, and thereby unnecessary hazards to the turbine are introduced.

The turbine manufacturer cannot be responsible for any washing cycle, neither is he in position to outline boiler-feed treatments, or other operating schemes designed to solve the problem of carry-over. However, there is offered below a review of the various methods now currently used in removing deposits from steam-turbine passageways.

Methods of Deposit Removal

REMOVAL OF WATER-SOLUBLE DEPOSITS BY SHUTDOWN. All types of deposits tend to build up more rapidly under steady high-load conditions; and the soluble types are usually absent in turbines that are subjected to variable loads or frequent shutdowns. These observations lead to the most simple method of treating soluble deposits, namely, to shut the unit down for two or three days, or even longer, thus allowing the temperature of the entire

* From a Power Division paper presented at the Fall Meeting of the A.S.M.E. at Boston, Mass., Sept. 30–Oct. 3, 1946.

[1] Designing Engineer, Turbine-Generator Engineering Division, General Electric Company, Schenectady, N. Y.

[2] Superintendent of Turbine and Marine Installations, Service Engineering Division, General Electric Company, Schenectady, N. Y.

structure to drop. When restarting, condensation from the incoming steam is then picked up by the solids so that upon restarting a degree of washing is accomplished which may be quite effective.

Removal of Water-Soluble Deposits by Light-Load Operation. On installations where the initial temperature of the boiler drops with reduced load, soluble deposits can frequently be removed by dropping the load to a relatively light value for several hours each week. The machine should be operated on one control valve, with that valve in a wide-open position, thus avoiding the increase in superheat associated with throttling. Such operation advances the moisture region much nearer the inlet and thus produces a washing effect over those areas where the deposits are forming under higher-load conditions.

Saturated Steam Wash by Water Injection. This is the conventional and well-tried method. Briefly, it consists of a piping arrangement for the atomization and injection of water into the steam supply to insure a gradual and uniform reduction in the temperature of the turbine inlet steam until it reaches saturation, and is several per cent wet. That condition is then maintained until the soluble deposits are washed into the condenser.

During the entire wash the unit should be carefully watched for signs of rubbing or other distress. The effect of rubbing is much less severe at low speeds; therefore the wash should be conducted with the rotor turning at from one-fifth to one-quarter normal speed.

Solid water injection through a drain line into a header is hazardous since the water is most likely to flow along the bottom of the steam pipe in a stream, its cooling effect on the steam is not fully utilized and the casing of the turbine is then subjected to unusual strains.

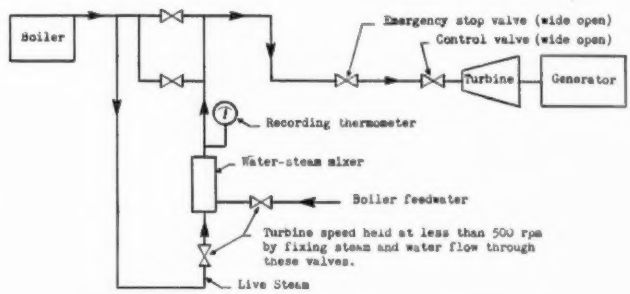
With installations of moderate pressure and temperature, water can rather easily be introduced through a suitable spray into the steam admission line. When the temperatures and pressures are high it is difficult to maintain saturation temperatures after admitting the water due to the throttling necessary to reduce the pressures. To avoid this throttling, with its associated rise in superheat, both the emergency stop valves and the control valves should be held wide-open during the washing operation. As this condition exists normally only with full steam pressure and at full load, a piping scheme has been devised, as here illustrated, that permits the admission of low-pressure saturated steam through a bypass around the main steam gate valve. This bypass line is arranged so water can be introduced and mixed with the bypassed steam.

Another important advantage associated with such an arrangement is that it is then possible to maintain relatively high steam velocities through the pipes between the point where the water is admitted and the first-stage nozzles. This feature was specifically designed for turbines having valves on the lower-half shell, or with stop valves located several feet below the turbine-room floor, in which cases it becomes necessary for the water to be picked up by the steam and carried vertically upward to reach the turbine.

It will be noted from the piping diagram that the steam is supplied from the main header on the boiler side of the boiler stop valve. When washing, this steam is mixed with boiler feedwater to obtain saturation of the steam, and the mixture is fed through the turbine in an amount just to sufficient run the turbine at the recommended low speed. It is advisable to use properly proportioned needle valves for controlling the water in order to insure an exact adjustment.

To start the washing procedure, operate the turbine off the line and at approximately one-fifth normal speed, but under control of the control valve. Close the boiler stop valve and open the live-steam valve to the mixer after which the control valves may be opened wide and the speed held at the proper value by the small live-steam valve to the mixer. Feedwater is then supplied through the mixing chamber in quantities sufficient to reduce the steam temperature at the recommended rate until the temperature of saturation is reached and enough more water is injected to insure saturated temperature throughout the turbine.

Saturated steam should be passed through the turbine for a sufficient length of time to remove the greater por-



Piping arrangement for washing turbines

tion of the solids deposited on the nozzles and buckets. The progress and effectiveness of the wash can be checked by analysis of the exhaust steam from the turbine (condensate samples) or by test samples from the stage drains.

To complete the washing cycle, the steam temperatures should be increased to normal by slowly shutting the boiler feedwater valve to the mixer; and as before, the rate of this increase should not exceed that previously specified for the type of turbine being washed. The control valves may then be shut to a point where pressure ahead of them is brought up to the line pressure, the speed still being held at approximately one-fifth normal. The boiler stop valve may then be opened and the turbine brought up to speed for the normal loading cycle. As an alternative, the turbine may be shut down entirely, then brought up in accordance with the usual cycle for a cold unit.

Noncondensing turbines should be washed at atmospheric back pressure in order to decrease the leakage of steam from the packings. If washing is attempted at full back pressure, a differential of at least 175 lb being needed between admission and exhaust, the flows become large with corresponding difficulty in realizing the required cooling.

As an aid in insuring proper temperature control, the installation of a recording thermometer is recommended in the steam inlet as close to the turbine as possible, or the use of thermocouples on the top and bottom of the inlet pipes. Lubricating oil should be checked after the wash for moisture contamination due to gland leakage.

Hot-Water Wash on Turning Gear. This procedure is one of the several ways soluble deposits can be removed. The unit must be shut down for several days in order to insure uniformly low temperatures throughout the structure, and to permit the hot water to soak off the deposits while the rotor is turning. With a single-casing machine the condenser steam space is filled with warm water up to the bottom of the turbine shaft which is slowly rotated on the turning gear. In the case of tandem units with top cross-over pipes, the high-pressure section can be so washed without filling the condenser with water.

The principal objection to this method is that unless the deposits are limited primarily to the rotor, it is extremely difficult, if not impossible, to effectively wash the top-half diaphragm partitions. Additional temporary supports are needed to carry the condenser load which is greatly increased due to the large volume of water in the steam space. The manufacturer does not favor this type of water wash.

Saturated-Steam Wash Under Load by Lowering Boiler Temperatures. With a modern unit-type high-pressure boiler and heat-exchanger-type temperature control, it is possible to lower the pressure at the throttle and also to realize a degree of desuperheating by the manipulation of the boiler and its accessories. This provides a way to wash a turbine under load when the flows are appreciably greater than for low-speed operation.

The maximum rate at which the temperature of the incoming steam may be changed without distress to the turbine is usually considerably higher than the rate at which the boiler itself can be adjusted, so the boiler becomes the limiting element.

If the boiler control will not permit a large enough temperature reduction to attain saturation, then water must be admitted with the incoming steam. Even with larger flows, the use of a stop-valve drain or some other existing drain line for the admission of a stream of water may have a seriously detrimental effect on the piping or on the turbine, or both. Therefore atomization of the water is necessary as is outlined.

Here it is well to emphasize again that any turbine-washing procedure involves some hazard, and a process in which the turbine is operated with load and at full speed is more hazardous than one in which the load is zero and the speed is low. Perhaps the most serious danger with this procedure is that if a turbine is quite dirty, the operators may wash the deposits from the earlier stages down into the lower stages and then completely plug up a stage with a consequent rapid rise in pressure across that stage and with danger of a failure resulting. This danger is lessened if a turbine is washed regularly before any appreciable deposits are accumulated.

Caustic Soda Wash for Removal of Water-Insoluble Deposits. The deposit of a water-insoluble silica precipitate on turbine nozzles and buckets is now causing some trouble in turbine operation.

The washing of turbines with condensate removes little if any of the silica deposit. Turbines with silica deposit have been washed with sodium hydroxide and this procedure will probably be developed into a usable technique. However, the losses in capacity and efficiency due to deposit are costly and aggravating, and means for preventing the deposit would be much more desirable than means of cleaning.

Caustic washing under load offers objections similar to those previously reviewed, and in addition, it is not yet definitely known if the residual accumulations from this procedure will have a detrimental effect on bucket fits or other internal parts of the turbine.

The following suggestions are not intended to be the turbine manufacturer's recommendations pertaining to a well-established procedure; rather, they represent a summary of the results experienced in a number of cases where the operators have been desirous of using this method and have requested guidance in the process. Several broad generalizations may be considered:

It is desirable to keep the caustic solution away from valve-stem packings; otherwise it will be necessary to renew the packings. Therefore the caustic solution should be introduced after the governing valves, if this is possible. In the case of nitralloy bushings it may be possible to use the leakoff lines for the admission of saturated steam or pure condensate which will keep the relatively small clearance spaces between the stems and the bushings free of caustic accumulations. The valves should be moved through their stroke several times during washing procedure to insure removal of any deposit.

A final washing should be sufficiently thorough to remove all caustic from out-of-the-way passages and pockets. Bleed connections, shell drains and instrument connections should be closed during the wash, then afterward opened and flushed until all residual caustic is removed. It is good practice, if practical, to provide a means of accounting for all the caustic used so as to reveal any accumulation of the solution in places where it is not wanted.

The corrosion resistance of the packing springs in diaphragms and high- and low-pressure packings will be somewhat reduced since the corrosion-resistant coating used on most of these springs is definitely attacked by the caustic solution.

The washing should always be performed in a wet atmosphere and the solution should have an initial quality sufficiently low to assure moisture in the exhaust.

A speed of rotation from one-fifth to one-fourth of the operating speed has proved to be effective during the injection and washing periods, and even with smaller machines the speed should not exceed one-third rated speed of the turbine.

The caustic injection solution is usually a 10 per cent solution of sodium hydroxide. This is added in gradually increasing quantities replacing equal quantities of injection water, so that the turbine will continue to rotate at the desired speed with the proper amount of moisture.

A suggested caustic-washing cycle follows:

1. Drop turbine speed to from one-fifth to one-fourth of the normal operating speed.

2. If the turbine operates noncondensing, change gradually from rated back pressure to atmospheric exhaust pressure, maintaining the speed range just mentioned. If the turbine operates condensing, decrease the vacuum gradually until the exhaust pressure is between 5 in. and 10 in. Hg abs, maintaining speed constant by increasing admission steam.

3. Inject sufficient water to obtain saturated steam in the exhaust. The rate of injection of cooling water should be such that the incoming steam temperature is not dropped faster than the maximum permissible for the rating involved. The injection water should be thor-

oughly mixed with the steam to avoid water slugs that would suddenly cool any parts.

4. Begin injecting the 10 per cent caustic solution, reducing the desuperheating water by the same amount, so both the temperature and speed will be maintained constant. Continue to decrease water and increase caustic until all desuperheating is done by caustic solution. Caustic supply pipes require flushing to prevent plugging.

5. After pumping caustic solution at the foregoing rate until the exhaust pipe drip shows the presence of caustic, the turbine should be shut down for fifteen minutes to allow the solution to soak into the deposit.

6. Again bring the turbine up to from 750 to 1000 rpm desuperheating with the same amount of caustic solution as before, and run for fifteen minutes. Analyze the exhaust drip for silica toward the end of each caustic injection period.

7. Shut down turbine for fifteen minutes.

8. Repeat the injection and rest cycle until the exhaust drip shows negligible silica.

9. Wash the turbine with saturated steam until neither caustic nor silica shows in exhaust drips. The exhaust drip should show maximum silica during second or third caustic injection and should decrease thereafter. Condensate should be dumped during the wash.

10. Replace all soft packing exposed to caustic.

One operating company prefers to introduce the caustic solution into a hot machine, the underlying theory presupposing that the caustic soda solution coats the affected surfaces and is evaporated by heat until it reaches a highly concentrated state. During the process of concentration the caustic soda is believed to convert the silica to sodium silicate which is water-soluble and is then removable at a point where there is approximately 150 deg. F superheat.

This same operating company has found that a start-and-stop cycle during the flushing period is more effective in cleaning the machine than continuous running. Consequently, after reaching saturation temperature, a cycle of one hour running and one hour on turning gear is instituted. The speed at which the caustic injection and flushing is done is alternated first at 1000 rpm and then at 600 rpm on a 3600-rpm unit.

ACID CLEANING. There has been some thought given to the use of hydrofluoric-acid vapor as a means of dissolving silica, although a more practical acid cleaning and one once used, involves the disassembly of the turbine and placing the rotor over a tray containing about a 10 per cent solution of hydrofluoric acid. The liquid comes up to the base of the blades only, and as the rotor is slowly turned, all the blades come in contact with the solution. Later, a thorough neutralizing treatment is necessary, followed by a water wash.

None of these more severe treatments is favored by the concern with which the authors are associated. Acid enters the bucket fits where it is next to impossible to remove it all, so damage may be done later on by corrosive action.

REMOVAL OF WATER-INSOLUBLE DEPOSITS BY INCREASING STEAM TEMPERATURE. Certain theories as to the formation of solids as the steam passes through its temperature cycle lead to the conclusion that the precipitate may be dissolved again and pushed on through the turbine by raising the temperature of the steam in those areas where the deposition occurs. It is difficult to realize such an increase in actual practice and such data as are available indicate this procedure is satisfactory only when the deposits are soluble.

MECHANICAL CLEANING DURING INTERNAL INSPECTION. It may finally be necessary to resort to mechanical cleaning in order to remove completely deposits from steam-turbine passageways; and in any event this is usually done during periodic overhauls. Hand files, scrapers, emery cloth and other such devices are often used for this operation but the buckets may thus be left with scratches and marks and it is extremely difficult to get all the solid matter out in the early stages where the buckets are small and close together.

About the best-known method of cleaning out steam passageways during inspections is by means of a fly-ash blast. Many other abrasives have been tried but sifted stack ash from pulverized-coal boilers offers the best-known material for this work. A smooth satin finish results and with proper care the parent metal will not be cut away to any extent during the removal of the deposit.

Discussion

W. S. Patterson of Combustion Engineering Company pointed out that boiler manufacturers recognize the desirability and necessity of delivering pure steam, not only because the turbines require it, but to guard against trouble in superheaters. He considers that the correction of mechanical carryover, which is one of the causes of steam contamination, is a joint problem of boiler design and water treatment.

Contamination by the vaporization of solids or by the solution of solids in steam can be reduced by limiting the concentration of silica as much as is economically feasible. It was brought out that silica in steam is reduced by contact (during washing) with feedwater of low silica content.

He stated that boiler manufacturers consider 1 ppm of impurity as a reasonable minimum at present although some boilers have operated with less than half this much even at maximum load. As there is no reliable means of determining contamination in steam below 1 ppm, improvement of apparatus to further reduce it becomes a difficult problem.

He told how the evaporation method which was developed by Combustion Engineering research obtained results down to about 0.30 ppm total solids. This was used in connection with a research program being carried out at Somerset Station of Montaup Electric Company of which a series of A.S.M.E. papers pertaining to the forced-circulation boiler there has already been published. Assuming that impurities in the steam can be reduced to 0.10 ppm the fact remains that a 1,000,000-lb per hr boiler will discharge solids at the rate of 875 lb per year. Conceivably, turbines will still collect sufficient deposits to require cleaning.

Variables in the boiler water and contamination of the feedwater, which affect the composition of the solids carried to the turbine cannot be controlled by the boiler manufacturer.

In the average case it is the water in the wet steam that carries dissolved solids out of the boiler and separation of this water is more difficult in high-pressure boilers than it is in those operating at low or medium steam pressures.

A.S.M.E. Fall Meeting at Boston

A well-attended Fall Meeting of the American Society of Mechanical Engineers was held in Boston from September 30 to October 3. The many interesting papers on a variety of subjects which were presented at morning, afternoon and evening sessions, together with several inspection trips, including the Lynn works of General Electric, B. F. Sturtevant Company and Mystic Station of Boston Edison Company, and special luncheons and dinners made the program a very full one. The technical sessions were devoted to heat transfer, management, hydraulics, fuels, wood industries, production engineering, textiles, aviation including jet engines, education and training, power, metals, machine design and industrial instruments.

The guest speakers at the special luncheons and dinners included the **Hon. Maurice J. Tobin,** Governor of Massachusetts, who extended greetings from the Commonwealth; **Eugene W. O'Brien,** President-Elect of A.S.M.E.; **Rear Admiral M. L. Deyo,** Commandant, First Naval District; **A. C. Klein** of Stone & Webster Engineering Corporation; and **H. A. Winne,** vice president of General Electric Company.

Twenty Years of Progress in Industrial Oil Firing

This paper by **Rene J. Bender** of the Sinclair Refining Company tells of the contribution of the U. S. Navy to the progress in utilizing residual oils including a study of the ash problem, followed by a description of the three main types of industrial oil burners. Also discussed was the need for coordination between burner manufacturer, boiler designer, fuel supplier and consumer as essential for correct selection and proper operation of oil-firing installations. Although spectacular changes in the art of refining crude oil took place as a result of war demands for new petroleum products, especially aviation fuels, from 15 to 30 per cent of residual fuel oil continues to be produced from the crude. The yearly production of this oil for industrial use amounts to 335 million barrels. Industrial oil burners installed in this country, exclusive of those on U. S. Navy vessels, number about 350,000. Work inaugurated at the Naval Boiler and Turbine Laboratory at Philadelphia Navy Yard before the war was responsible for the satisfactory, trouble-free use of heavy fuel aboard ships.

As a result of the development work done by the Navy, new requirements were set up for a fuel designated as Navy Special Fuel Oil for consumption on all combat vessels.

Another study undertaken by the Navy is that of the action of the ash in fuel oil. This ash contains inorganic salts of sodium, calcium, magnesium, manganese, iron, nickel and vanadium which is concentrated in the residual fuel after refining. Although it amounts to only one-half of one per cent of the total oil, the accumulation of ash in a boiler can be considerable after a long period of operation.

Some of the troubles which this ash can cause are: formation by certain metallic components of a eutectic combination with the firebrick with a melting point as low as 1600 F and the collection of ash on the boiler and superheater tubes. In the latter instance when superheaters are located in hot gas zones the ash carried in the gases sublimates between 1400 F and 1800 F causing deposits of stonelike accumulations of slag partly soluble in water, and which are very hard to remove mechanically.

Not only the amount of ash in the fuel oil but its nature must be watched. Vanadium, in particular, has a deadly cementing effect in addition to its tendency to combine eutectically with firebrick.

The responsibility for reducing the ash problem lies with the refiner, the boiler designer and the operator. The refiner can select crude oils more carefully and remove objectionable salts from some. The boiler designer can select proper refractories, the proper burner for correct flame shape and flame travel, design the boiler and superheater with liberal tube spacing and avoid cross flow, if possible, and select the proper metal for all areas likely to be damaged by action of certain ash components. The operator's part consists of the establishment of a systematic inspection and slag-removal program.

The industrial oil burners discussed were the steam and mechanical atomizing and the horizontal rotary-cup types. The steam types can burn almost any kind of liquid fuel of any viscosity and temperature but due to the steam required (up to two per cent of the total generated) are generally employed only when cheap steam is available or the grade of fuel requires this type. Steam atomizing burners are divided into "pre-mixing" where the steam and oil are mixed inside the body or tip, and external mixing, where the oil emerging from the burner is caught by a steam jet.

Mechanical atomizing burners which in the past were limited to only about a 40 per cent range in capacity, necessitating the use of several burners per boiler, have recently gained importance with the introduction of wide-range tips. With such tips and using oil at 500 psi to the burner a range of 14-to-1 is not uncommon. Other types to operate on oil at 900 psi to give a range of 20-to-1 are being developed. An application of the wide-range mechanical burners is found in the Harbor Steam Plant of the City of Los Angeles. This boiler of 675,000 lb per hour capacity is fired by ten Peabody combined gas and wide-range oil burners. As this boiler was installed for standby capacity the need to pick up the load from 70,000 to over 600,000 lb of steam per hour in five seconds has been demonstrated already.

In the rotary-cup oil burner, oil is atomized by centrifugal force as it leaves the rim of a horizontal cup, troconical or cylindrical, rotating at 3500 rpm. No pressure is required other than that to bring the oil to the cup. This type of burner is of advantage where only low-pressure steam is available, hence where high oil preheat temperature necessary for mechanical atomization cannot be obtained; also where higher viscosity

oils, say of 300 Saybold seconds can be used (150 being necessary for proper mechanical atomization).

Discussion

A. J. Poole, of the Babcock & Wilcox Company stated that the oil ash is more difficult to handle than coal ash although representing only one-half of one per cent of the fuel, because of the slagging conditions produced. In the furnace the slag deposits are generally limited to a thickness of $^1/_{16}$ in. while in the superheater it can continue to build up until it bridges over between the tubes. This condition becomes severest at the higher operating temperatures producing slag that is difficult to remove mechanically. As it is soluble in water, it can be removed during shutdowns by continuous washing with water sprays in about six hours. During operation of the boiler, hand lancing by either rodding or using steam lances will keep slagging conditions in check. Water, if used during operation, should be applied with extreme caution.

Mr. Poole emphasized the various steps necessary to reduce the slagging problem to a minimum and pointed out that adequate means for cleaning boilers both during operation and shutdowns should be provided.

It was stated by another discusser that there was a project in South America to extract vanadium from fuel-oil slag.

Packaged Boilers

Martin Frisch and **H. H. Hemenway,** of Foster Wheeler Corp., described types of packaged boilers that were developed during the war to meet special requirements. These boilers are shop-erected steam generators, shipped completely assembled or in subassemblies which can be installed quickly with minimum labor.

The forerunners of these types were two portable water-tube steam generators with integral separately fired radiant superheaters that were built for use in the oil fields, where formerly portable fire-tube boilers were used. The need for power in devastated areas of Europe during the war created a demand for some sort of small plant that could be transported readily. This was met by construction of the power trains, floating power stations, packaged power plants, etc.

The chief requirements of the packaged boilers are: compactness, simplicity and reliability.

Compactness was necessary in order to meet civilian and military rail transportation requirements while being shipped as a unit or in subassemblies. Strength is an important requirement to stand the handling in transit.

Due to the fact that this type of boiler was designed primarily to operate in foreign countries where operators had to be trained quickly, simplicity was essential. Furthermore, as field erection was generally by unskilled labor it was necessary that the unit fit on a prepared foundation and be ready for immediate operation.

Reliability was essential as most areas served by packaged boilers were generally extremely dependent on them. Units had to be self-starting since they were intended for areas having no other source of power.

The first of four wartime designs described was for use in Russia. The boiler which was for a 1000-kw power plant is a cross drum type having a capacity of 16,000 lb of steam per hour at 405 psi and 750 F, and was designed to burn Russian coal, lignite or peat on a spreader stoker. These units were shipped in subassemblies, the largest of which was the boiler and furnace unit weighing 33 tons. The actual time for erection of the steam generator and accessories by a construction crew not specially trained was 33 hr and 641 man-hours.

The second example of a packaged boiler is the SA type for a 500-kw steam power plant. This boiler consists of a longitudinal steam drum connected to two smaller water drums approximately the same length by boiler tubes on both sides of the furnace. The inside row of tubes on each side constitutes the furnace tubes and is separated from the remainder, or boiler tubes, by castable refractory baffles. A spreader stoker is set between and below the two water drums. The gases on leaving the furnace divide and enter the tube banks on either side passing forward to the flue located at the front of the unit. An interesting feature is that the superheater tubes are directly connected to the steam space between chevron driers in the steam drum thus eliminating the usual superheater header.

The third example is an oil-fired boiler to provide 31,630 lb of steam per hour at 425 psi and 760 F for a 2000-kw power plant. It consists of two drums set longitudinally with the maximum drum center distance that railway clearances will permit. Gas flow is from front to back in the furnace and back to front in the tube bank. With a regenerative air heater this unit operates at 84.5 per cent efficiency.

The fourth example is a complete single-pass boiler approximately 5 by 6 by $8^1/_2$ ft with auxiliaries all mounted on a common base plate the entire unit weighing 10,500 lb. This unit generates 3000 lb of steam per hour at 100 psi. One motor drives the water and oil pumps, and the forced-draft blower. An interesting self-starting feature is the use of a steam jet ring in the base of the stack which is connected to the superheater for the double purpose of providing draft and also protecting the superheater. A wood fire is used for starting up.

Furnace release rates vary from 20,000 in type one to 217,000 Btu per cu ft per hr in type four. On the larger unit (type three) the release rate is 56,500 Btu per cu ft per hr.

As the packaged boilers must operate reliably on good and bad feedwater, a softening plant was generally furnished with each unit. Even with reduced blowdown steam purity has been good.

It was pointed out that these types of boilers may find many uses in peacetime for temporary, emergency and permanent installations.

Discussion

J. E. Tobey of the Fairmont Coal Bureau, told of a recent survey of 15,000 boilers in the U. S. and 7000 in Canada averaging in size 174 hp in the U. S. and 141 hp in Canada. It was found that many of these were operating at low efficiency due to the condition of the settings, doors, etc. Many had been poorly assembled. This survey indicated a need for water-cooled furnaces

and opens a large market for replacement boilers of the "packaged" type. Pre-assembled boilers would eliminate the bad practices of the past. He also pointed out a need for a "push-button" boiler for coal firing having automatic coal- and ash-handling facilities.

A question from the floor as to why locomotive-type boilers were not used for this service was answered by Mr. Frisch wherein he pointed out that they cost more and were limited to pressures lower than the present-day trend.

Single-Retort Underfeed Stokers

Ollison Craig, engineering manager, Riley Stoker Corporation, led a panel discussion on this subject in which he covered the basic considerations for the selection of single-retort underfeed stokers. These considerations were cost, capacity, control and convenience. This type of stoker is economical to operate and is capable of delivering maximum output with complete control while representing a minimum amount of equipment. Furthermore, the ease of operation of this type of stoker results in nominal labor costs.

As this stoker may be employed in establishments not operating continuously, the design must be predicated on frequent shutdowns. For this reason it has been recommended that these units more than ever be a push-button proposition.

Discussions

Opinion was sought on the small experimental stoker at Pennsylvania State College which when burning strong coking coals without benefit of overfire air does not produce coke trees.

This was answered by one who had participated in the tests, and explained that the stoker was small enough to get air admission in the retort. For retorts over 5 ft long and for industrial use, this stoker would require overfire air.

Earl C. Paine, consulting engineer for the Pittsburgh Consolidation Coal Company, took the point of view of the user. He stated that in the field of small stokers, poorer engineering of installations is experienced. This is especially so for conversion jobs. Part of the engineering job today should include means for handling coal and ash and the employment of instruments to insure ease of operation.

To obtain the best overall satisfaction, the stoker should be large enough to burn coal with the most difficult characteristics and the performance should be based on this coal. The equipment manufacturer should provide the proper advice. The burning rates should be set at the maximum limits without producing objectionable clinker. Based on coal obtained in the Boston area (size $1^1/_4 \times 0$, ash 6.7 per cent, ash-fusion temperature 2050 F and heating value of 13,500 Btu as received) a combustion rate of 25 lb of coal per square foot of grate area per hour was recommended. This can be increased by 2 lb for continuous agitation, by 5 lb for a water-cooled furnace and by 5 lb when double-screened coal such as $1^1/_4 \times {}^3/_8$ in. is used. With all these advantages a maximum rate of 37 lb can be obtained.

H. E. Winkler, vice president of the U. S. Machinery Corporation, stated that these stokers are used mostly for heating and processing work such as in laundries and are used with boiler pressures generally not exceeding 150 psi. He feels this field has been neglected by engineers. The engineering, sales and maintenance are usually in the hands of a coal dealer or a specialty house. Efficiencies are rarely discussed in this field. The type of persons operating this size unit is not generally conversant with engineering terms.

He felt that the manufacturer should provide proper drawings including the bridgewall, ash pit, etc., of a well-engineered installation and recommend proper controls. He stated that this type of equipment will pay for itself in one to three years (on a fuel-saving basis alone).

I. L. Nevells, of the Stoker Department of Westinghouse Electric Corporation, stressed that the operator should have dependable instruments. The psychological effect of a steam flow-air flow meter is good. Automatic controls should have simple means of adjustment. Instruments must be checked and readjusted periodically. The importance of tight boiler settings was also stressed.

With larger stokers the best results are obtained when operating with the thinnest possible fuel bed to maintain low excess air. One cannot depend on building up a reserve in the fuel bed to take care of load swings. To insure good operation it is necessary to distribute the coal uniformly, promote rapid combustion and prevent coking and caking.

Otto de Lorenzi, of Combustion Engineering Company, stressed the need for overfire air or steam jets for single-retort stokers in order to get a mechanical mixture of the alternate layers of rich and lean streams in the furnace. Overfire air cuts down the length of the opaque flame over the retort and reduces smoking.

Eric Smith, chief engineer of the Stoker Department, Riley Stoker Company, showed some slides of installations where troubles were experienced. Some of these were too large a fan, improper regulator connections and improper sampling of CO_2. He warned that predictions concerning trouble with stoker installations should be withheld until a careful on-the-job inspection is made.

Pulverized Coal Furnaces

This portion of the second session on Fuels was devoted to the showing of a color motion picture of pulverized-coal furnaces in operation filmed and described by **Otto de Lorenzi**. By the use of color, the mixing of coal and air at the tip of various types of burners was vividly shown. Many other views showed the action of pulverized-coal firing by vertical, horizontal and tangential methods.

Overall Professional Organization Proposed

Pertinent to the present situation where pressure is being exerted by trade unions and when many engineers reluctantly have become members of labor unions, a timely report on "An Immediate Measure to Strengthen the Professional and Economic Position of the Engineering Profession" was presented by **C. W. Ransom** at the session on Education and Training. This report was prepared by the National Societies Committee for the General Electric Engineers Associations with the assistance of the A.S.M.E., the A.I.E.E., the N.S.P.E.

and the American Association of Engineers. It proposes to integrate the professional and economic interests of engineers into a single dynamic national body that would strengthen their standing and economic status and at the same time establish solidarity within the profession, far better than can be done at present by the many separate societies, whose principal functions are technical.

It is recommended that all the engineering societies be invited to participate; that the body be run by nonsupervisory engineers, elected by the membership; and that they would be responsible to the membership rather than to the governing bodies of the sponsoring societies. It would have state and local chapters. The initial operations would be financed by grants from the sponsoring societies whose members during this period would be considered members of the new organization, although qualified engineers, not members of the sponsoring societies, would be given the opportunity to join. After the initial period of organization and operation the new body would become self-sustaining through nominal dues of members.

Believing that the engineer does not want a representative to deal with his employer concerning his salary; that he does not favor salary rates negotiated by an organization responsible to the majority, which is under compulsion to act in the interests of the median group and thus restrict reward for merit; and that he is adverse to a paternalistic system whereby someone else handles his grievances, the report suggests that the economic status of the engineer could be met by the proposed organization achieving the following objectives:

1. Equitable compensation relative to nonprofessional employees, with sufficient spread in the engineering salaries to take merit into account.
2. This to be brought about through the collection and publication of data on how engineering salaries compare with those of other professions; also, as between the various types of engineering work.
3. Establishment of an employment service in which the salaries paid by various employers are correlated with other factors.
4. A program for continuing education after leaving school to develop the value of the individual and justify a higher level of remuneration.

These activities, and others, to be so integrated as to give maximum freedom of action and opportunity to contribute to the common good of the engineering profession and to society.

It is believed that an organization established and functioning along the lines proposed would go far toward placing engineering among the learned professions, along with theology, law, and medicine.

Do engineers need collective bargaining? Do they need to sit down at the conference table with management and discuss their relations with management and labor, working conditions, salaries, etc.?

An attempt to answer these questions was made in a paper by **Raymond L. Forshay,** an associate member of the A.S.C.E. and one of the staff of TVA, who had been active in the formation of the Tennessee Association of Professional Engineering Employees during construction of the atomic bomb plant at Oak Ridge. In this instance, he stated, the engineers' only choice was to organize or be represented by the A F of L.

Mr. Forshay cited a number of other cases, particularly those on the Pacific Coast, where engineers' associations are functioning for collective bargaining on a professional level. In most instances these associations were formed as defensive measures to preclude forced representation by heterogeneous groups. Their contracts with management are usually quite different from those of labor unions and fully recognize the responsibility of management to provide differentials in pay in recognition of merit and efficiency, and the determination of employee performance with respect to selection of those to be promoted, retained or discharged.

Discussing the attitude of the National Labor Relations Board, as indicated by numerous decisions affecting engineers, the paper emphasized that the Board is not concerned with preserving the professional status of engineers nor their educational background, but is guided by their actual duties. Those that have supervisory duties may or may not be excluded from professional groups organized under the Act, depending upon the degree of supervision involved. However, while the Board has recognized the interests of the professional employees as being different from those of trades and labor or industrial union groups, it nevertheless is not likely to redivide a group already formed.

In conclusion, Mr. Forshay observed that "we all would prefer to have such problems handled through our established engineering societies; that few engineers will question the need for an overall engineering society similar to the American Medical Association or the American Bar Association; but engineers, who have been noted for their ability to organize physical things and have contributed in large measure to the world of today through applied sciences, have so neglected the development of the social sciences as to be caught in the wake of the mechanical giant they created."

Discussion

W. F. Ryan, of Stone & Webster Engineering Corporation, stated that he believed organization of engineers by labor unions would spell the doom of the engineering profession.

He advocates formation of a single engineering society to provide the same benefits to engineers that the American Medical Society does for the medical profession.

S. Gilman, of Westinghouse Electric Corporation, stated that he could see no advantage in myriad groups of small independent engineering organizations. He feels that engineers are faced with loss of identity as industry absorbs them or as labor unions try to force them into the ranks. He told how the engineers at the Westinghouse Bloomfield Works, although salaried employees, were convinced by the CIO to join their ranks and a local engineers' union was formed. A strike vote was taken in December 1945 and in January the strike which was in violation of the charter was called. With that the engineers resigned in a body and formed their own organization after receiving legal counsel. He stated that their engineers are still represented by the CIO but receive no benefits therefrom. The union has written each inviting them to rejoin. He felt that en-

gineers showed a lack of social understanding and political agressiveness.

I. M. Stein, vice president and director of research, Leeds & Northrup Company, speaking of the bargaining of engineers believes that discussions should be confined to the professional group in any particular company or organization. He doesn't believe the handicap of lack of coordination between groups is so detrimental to the success of engineers. Speaking of the compensations of engineers as a group compared with other professions, he feels they are on a par with doctors and lawyers.

Prof. Wm. J. King, head of School of Mechanical Engineering at Cornell University, remarked that engineers are going to have some kind of organization of their own and they don't want the union kind. Engineers' interests are not contrary to those of management. He thinks management would be well advised to facilitate and cooperate with such organizations but not absorb it. Present engineering societies should exercise more initiative in guiding this movement.

Atomic Energy Discussed

Speaking at the banquet on October 2, **A. C. Klein,** engineering manager of Stone & Webster Engineering Corporation, which had been identified with construction of the Manhattan Project at Oak Ridge, dealt with the industrial future of atomic energy. He predicted that the task of converting atomic energy into steam or electricity would equal in magnitude that of constructing one of the major atomic bomb plants and that from three to five years would be required. Moreover, after the project is solved from an engineering standpoint, it will not necessarily be economically sound. Only continued operation of atomic energy plants for a period of years, with accompanying improvements in design and operating techniques, can lead to cheap atomic power. This would take at least ten years.

The extent to which atomic power, after such development, may supplant coal and other fuels, Mr. Klein believed limited; and that there is room enough in the growth of our demand for power to absorb all the uranium that is likely to be produced and at the same time keep our coal mines, oil wells and hydroelectric plants operating at normal capacity.

Inasmuch as an atomic energy unit is inherently a large-scale device only the very largest consumers of power would be able to consider operating their own atomic energy plants. In fact, it is anticipated that the first commercial plants to be built are likely to be of the order of hundreds of thousands of kilowatts capacity.

On the military side of the question, Mr. Klein observed that "no one who has gone through the engineering and development work which led to the production of bombs can do other than conclude that it will be a decade before any other nation can vie with us in atomic bomb production; and our research program, if implemented with proper engineering development, will keep us in the forefront for a generation at least. During that time it behooves us to settle the international situation so that it will never again arise to threaten us."

In conclusion, the speaker advocated that a "Division of Atomistics" be added to the A.S.M.E. professional divisions and, further, that of the nine members of the Advisory Commission for atomic energy, to be appointed by the President, five should be engineers.

H. A. Winne, vice president of General Electric Company, spoke on "Power—Where Do We Go from Here" at the October 3rd luncheon meeting. He reviewed the tremendous advances made in the generation of power from fuel, particularly that for public utilities. He told how efficiencies were gradually improved with the attendant decrease in coal consumption through the increase in operating pressures and temperatures. Also covered was the development of the "Emmet Mercury Vapor Process," with mention of the early plants of this type in which the station heat rate was close to 10,000 Btu per kw.

Continued advances by the utilities industry will be marked by use of better cycles, higher pressure and temperature accompanied by improved metallurgy of metal parts and better turbine-blade design. Improvements of the mercury vapor process are anticipated. A great deal of attention will be paid to the use of stationary gas turbines of which there are several units already in operation in various parts of the world. It is felt, however, that the most attractive applications of the gas turbine will be in fields where its size, weight and simplicity will be in demand such as aviation, marine and railroad locomotive.

Looking into the future we encounter a new, but much talked of, possible source of power-nuclear, or atomic energy. As atomic energy is a source of heat, there does not seem to be a practical way of converting it directly into usable electrical power in significant quantities. We may look for the atomic power plant of the future to consist of the nuclear reactor, or so-called "pile," which will generate heat by fission and transfer it through some intermediate means to a more or less conventional power-generating unit such as a steam turbine, a gas turbine, or a unit utilizing the vapor of mercury or some other substance. A pilot or development plant of this type is already being engineered at Clinton Laboratories, Oak Ridge, Tenn.

Mr. Winne believes that in time production of electrical power from atomic energy will become an important factor, but that time may be from ten to thirty years away. He looks for atomic energy to supplement and complement our present power sources—not to replace them.

NEW RESEARCH PROGRAM

Anthracite Institute has just completed arrangements for a four company research project at Wilkes-Barre, Pa., which is expected to provide unprecedented facilities and personnel for experimentation with various phases of the gasification, oxygenation and pelletizing of the small sizes of anthracite and anthracite fines.

The companies involved in this program are The Wellman Engineering Company, Air Products, Inc., J. F. Pritchard & Company, and Anthracite Institute which will supervise and execute the general research program. In this they will be assisted not only by the previously mentioned companies, but also by other companies and institutions that may later be included.

The Engineer's Stake in Research

Dr. Jos. W. Barker, president of Research Corporation and former dean of the School of Engineering, Columbia University, addressed the New York County Chapter of Professional Engineers at their Chapter Club Rooms, 2 Park Avenue, October 3, on the progress of Applied Scientific Research.

Dr. Barker emphasized the value of long-range research as the source of new and greatly improved fundamental developments in industry. It often takes courage and foresight on the part of management to maintain such long-term programs in years of uncertain outlook and when faced with the necessity of curtailing costs. The properly established research laboratory, however, has come to be regarded in many industries as one of the most essential of their activities.

Increased Industrial Research Prophesied to Meet Demands

In this post-war era, applied scientific research privately financed will be on a much greater scale than before the war. Pent-up demands for goods and services, coupled with replacement of obsolete equipment, the conversion of large units of industry from wartime to peacetime production, and rebuilding the devastation caused by war, will make unprecedented demands upon the research facilities of industry.

Wartime researches were conducted intensively with a single circumscribed objective in view in each case, whether it was the bazooka, the atomic bomb or radar. Although the whole field of wartime research was extremely broad in scope including such diversified end products as penicillin, blood plasma, insecticides, etc., the objective in each case was closely followed, and the bypaths leading to other discoveries and improvements were noted but not explored.

Many of these byways may open up fertile fields for research investigations. Careful perusal and analysis of war research reports, issued as secrecy restrictions are lifted, should prove to be prolific sources of information.

Dr. Barker foresees a great shortage of trained and competent men to carry on in both pure and applied research and in the engineering profession. He cited four reasons for this shortage.

1. Industrial applied research laboratories are growing in total numbers and individual size. War-created industries are changing to the manufacture of new products.

2. There is a four-year gap, at least, in the education of scientists and engineers due to the operation of Selective Service during the war years.

3. The education of veterans under Government sponsorship has put a terrific load upon the teaching personnel of colleges and engineering schools. With shortages of trained teachers especially in the engineering and scientific schools, great difficulties are being encountered in re-establishing pure and applied research programs in these institutions.

4. Congress is expanding Government-sponsored research facilities in various departments and is considering measures to subsidize research in all fields, thus creating even more competition among an already depleted group.

According to Dr. Barker, the end result will be increased cost of privately sponsored research, which may prevent the establishment or maintenance of some vitally needed applied research, the lack of which may in turn handicap the development of a given company or industry. But he felt confident that applied research will have unparalleled opportunities in this post-war period in the development of a vast array of new and improved products.

Wartime production taught us valuable lessons in the essential interrelationship of pure and applied science, and engineering. Superb teamwork among scientists and engineers bridged the gap between the laboratory, the pilot plant and large-scale production.

The vastly greater diversification of new products and new methods of production needed in our peacetime economy impose even larger responsibilities upon trained men in science and engineering to build new improvements in man's living conditions.

John Fritz Medal Award

The John Fritz Medal and certificate, the highest award in engineering, has been awarded to Dr. Lewis Warrington Chubb, director of the Westinghouse Research Laboratories. The award was made "for pioneering genius and notable achievements during a long career devoted to the scientific advancement of the production and utilization of electrical energy."

Dr. Chubb's contributions to the knowledge of magnetic properties of iron and iron alloys, and his improvements in the design of electrical machinery and in the measurements of electrical and magnetic quantities, have had great influence in the development of the electric arts during the past thirty years. The breadth of his work is cataloged in about two hundred patents in electrical, mechanical, chemical and electrochemical, and welding fields, and for instruments. During World War I he was a member of the Naval Consulting Board advising on submarine detection methods, improvements in gas masks, sound ranging for directing shells, explosives and numerous other highly imaginative but potentially practical ideas. In World War II he contributed greatly to the development of the atomic bomb and also served on the N.A.C.A. Committee on jet propulsion, conducting a large research program on this subject. The John Fritz Medal is the honor awarded by representatives of four national engineering societies, the A.S.M.E., A.S.C.E., A.I.M.E. and the A.I.E.E., in memory of

John Fritz, one of America's great pioneers in the iron and steel industries. It is awarded not more often than once annually for notable scientific or industrial achievement, without restriction on account of nationality or sex.

Maritime Strike Slows Coal Exports

Maritime strikes have slowed down scheduled coal loadings for Europe to such an extent that relief and rehabilitation programs in the liberated nations are seriously affected, according to Solid Fuels Administrator J. A. Krug. Of the total of 1,921,000 tons allocated to the European nations for September, only 746,076 tons, or 38.8 per cent, were loaded in the first 23 days of the month. On this basis, it is anticipated that not more than 50 per cent of the September allocation will be delivered. The coal now being exported is in surplus supply in the United States and is first offered to buyers here before being sent abroad.

"It was hoped," said Mr. Krug, "that during September enough coal would be exported to permit a small amount to be distributed to domestic users during the cold winter months. Most of the coal exported since the program started has been used to power the railroads, to manufacture electricity and for the operation of industries. Without coal from the United States the rehabilitation of Europe and the relief of the civilian populations will be retarded seriously.

Out of the total tonnage shipped to Europe, the liberated areas received 461,360 tons, or 40.8 per cent of their allocation of 1,130,500 tons. Italy, whose allocation was 442,000 tons, received 197,831 tons, or 44.8 per cent, and other European countries, with aggregate allocations of 331,500 tons, received 78,493 tons, or 23.7 per cent. During August, Italy and the liberated areas of Europe received 1,876,308 gross tons.

During the past thirteen months, since August 1, 1945, when the Solid Fuels Administration for War began making available for export the coal that was not needed in the markets of this country, a total of 19,240,502 tons were shipped out. Liberated areas of Europe received 16,397,447 tons of this amount and it was used in augmenting native production to run food processing plants, generate gas and electricity for public utilities, operate railroads and for other industrial purposes. Although what we shipped was about one and one-half weeks' consumption in this country and consisted of sizes and qualities of coal that were in surplus amount, the fuel enabled Europe to move a long way toward economic recovery.

Failures in Steam Piping

Engineering of August 30 reports that a subcommittee of the British Electrical and Allied Industries Research Association is investigating the cause of a number of failures through cracking of 0.5 per cent molybdenum-steel steam piping. Pending results of the investigation it has been recommended that in piping for new power

stations and replacements, nickel and copper contents be kept as low as possible; and that all welding be given a final stress-relief treatment at 600 to 620 C, followed by slow cooling to 420 C from which temperature cooling off may take place in still air.

Similar treatment is recommended for all bends and for corrugated pipes after fabrication. Also, care is urged to insure that there is no surface damage by hammering or other causes which might create local residual stress after the thermal treatment has been applied; and hammering of an under hydraulic test should be avoided. Particular care should be taken to avoid sharp radii and sharp changes in surface contour, especially at the external valleys and any grooves, fissures or surface irregularities should be prevented or removed.

It is further advised that working stress at operating temperatures should be minimized wherever practicable, by making the thermal expansion stresses small or negligible. Accordingly, the "cold pull-up" should approach or equal the full thermal expansion, and the piping be designed on this basis.

One may wonder whether this trouble experienced in British power stations may not be similar to those experienced in this country about three years ago and finally traced to graphitization—Editor.

Mining Congress Opposes St. Lawrence Project

The western division of the American Mining Congress, meeting at Denver on September 12, went on record as strongly opposed to the Great Lakes-St. Lawrence deep waterway and power project as needless and unjustifiable. It took the stand that the enormous ultimate cost, not at first apparent, would impose large tax burdens, the waterway would be of principal benefit to foreign products and shipping, and the water power would merely displace more economical steam-generated power.

The Congress contended further that the project would tend to disrupt great mining and metallurgical industries and other essential enterprises of the Great Lakes Basin, where successful productive activities of a vast population are vital to the welfare and self-sufficiency of the country.

Permutit Acquires Simplex Valve and Meter

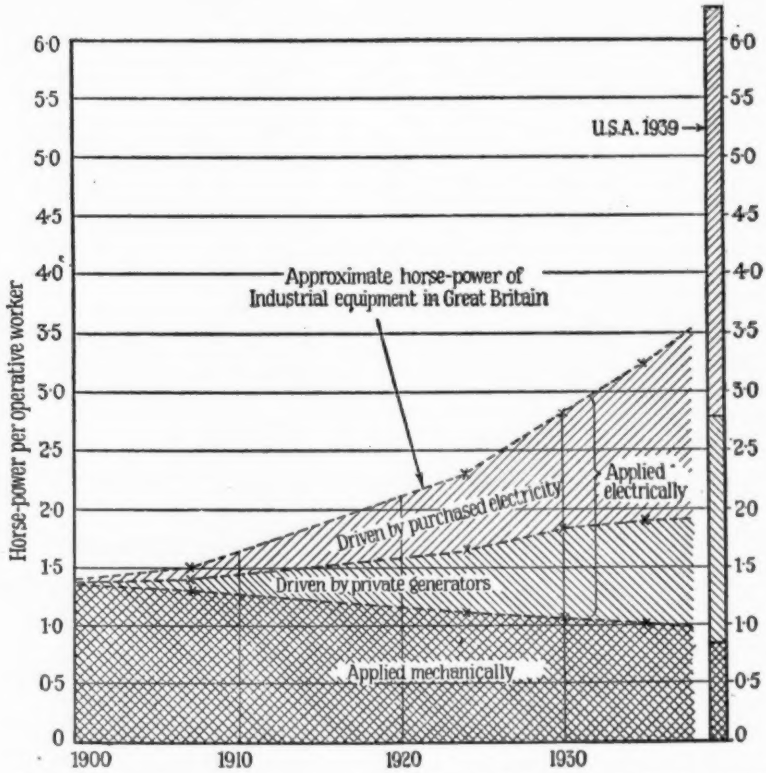
The Permutit Company, manufacturers of water-conditioning equipment, industrial ion exchangers and power plant specialties, has acquired the Simplex Valve and Meter Company of Philadelphia. H. W. Foulds, Permutit president succeeds W. H. Roth as president of the newly acquired subsidiary, while the latter becomes the Simplex Board chairman. The Simplex Company will continue to operate under its own name.

Horsepower per Worker in Great Britain

The August 1946 *Journal* of the Institution of Electrical Engineers (London) contains the accompanying chart, contributed by E. R. Wilkinson, which shows the installed horsepower per worker in the industries of Great Britain over the period 1900 to 1939. This is broken down into purchased and privately generated electric power and mechanically applied power, such as direct drive, and drives through belts and ropes. Although electric drive increased greatly over this forty-year period, it will be noted that the decrease in mechanical drive was gradual and that in 1939 it still accounted for about 29 per cent of the horsepower. Motors driven from public electricity supply and those from privately generated power expanded about equally until 1930, after which private generation remained nearly constant and purchased power expanded rapidly.

It will be noted that the chart also compares the horsepower per worker in Great Britain with that in the United States at the end of this period, showing the latter to be nearly twice as great.

No figures are yet available for postwar years in either country, nor will any such comparisons mean much until reconversion has been accomplished and normal conditions established.



Increase in horsepower per worker in Great Britain from 1900 to 1939

Open-Pit Coal Storage

Dry open-pit storage of subbituminous slack coal is recommended for industry in a publication released by the Bureau of Mines as insurance against coal shortages brought on by strikes, transportation delays, and mine deficiencies, as a means for reducing plant operating costs, and as a method for minimizing seasonal fluctuations in coal demand and unemployment in coal mines.

"Subbituminous coal can be stored successfully in open pits . . . with negligible loss of heating value . . . . if precautions are taken to minimize entrance and circulation of air," according to the authors of the publication, John B. Goodman, V. F. Parry, and W. S. Landers, Bureau engineers.

Containing the results of four years of study and observation on the best storage methods, the report is being made available to industrial coal users who, if they apply the information to fit their own requirements, would have ample operating fuel supplies on hand to meet unexpected contingencies and could profit from the lower freight rates and reduced mine costs prevalent during the off-season summer months.

Six methods of storing coal were investigated by the Bureau: in sealed air-tight bins or bunkers, in large formed piles with the sides and top sealed with asphaltic compounds, above-ground in coned piles with water-cooling sprays, underwater storage, surface storage with the coal mass compacted in layers and covered with fine coal, and dry, open-pit storage with the coal compacted in layers.

The dry, open-pit method proved to be the most satisfactory for other than very large consumers. This method is more

Three New Central Stations

L. D. Staver, president of Gilbert Associates, Inc., has announced that contracts received by his organization during the month of September include the following central electric generating stations:

A new station at Corning, N. Y., for the New York State Electric & Gas Corp. with 30,000 kw initial capacity and 60,000 kw ultimate. The first unit will be supplied with steam at 900 psi, 910 F by two boilers.

Another new plant will be constructed at Rochester, N. Y., for the Rochester Gas & Electric Company with 40,000 kw initial capacity and provision for an ultimate 160,000 kw. The turbine will be supplied with steam at 1250 psi, 950 F from a 400,000 lb per hr boiler.

The third installation is a 40,000-kw addition to the Gilbert Station at Holland, N. J., for the New Jersey Power & Light Company. Approximately 400,000 lb per hr boiler capacity will be installed in one or two units with steam conditions of 1250 psi, 950 F. The plans call for an ultimate capacity of 220,000 kw.

Obituary

Murray Kice, Jr., chief engineer of American Blower Corporation, Detroit, died on September 25 at Harper Hospital after a two-year illness.

Prominent in the heating and ventilating industry as a writer of many published articles, he was active in the American Welding Society, Engineering Society of Detroit, Economic Club, American Society of Heating & Ventilating Engineers, and American Society of Mechanical Engineers.

Mr. Kice was born in Louisville, Ky., in 1893 and received his college training at Purdue University from which he was graduated in 1915 with a B.S.M.E. degree. Immediately following graduation, he began his lifelong association with American Blower. Beginning as a mechanic in the fan shop, he soon became a sales engineer, successively in charge of the Columbus, Cincinnati, and Indianapolis territories.

Dr. Robert L. Sackett, for many years Dean of the School of Engineering at Penn State College and for several years past a member of the staff at A.S.M.E. Headquarters, died at the Hotel Sheraton, New York, on October 6. He was seventy-seven years old.

A native of Michigan, Dean Sackett graduated in civil engineering from the University of Michigan in 1891 and was professor of sanitary and hydraulic engineering at Purdue from 1907 until 1915 when he went to Penn State, becoming dean emeritus in 1937.

He was long active in the American Association for the Advancement of Science and in the Society for the Promotion of Engineering Education, as well as the Engineers' Council for Professional Development, in each of which he had held office. An authority on drainage and sewage problems, he had written extensively on these subjects. Surviving is his son, Dr. Ralph L. Sackett, professor of economics at the University of Miami.

Continued from page 56

economical, permits practical handling of large quantities, allows for periodic removal and is safer, the report states in pointing out six general considerations for successful dry open-pit coal storage. The essentials, according to the report, are tight pit walls, well-mixed coal sizes, several packed-coal layers, uniform compaction, level surface, and fine-coal topping. The three major objections to large stockpiling of coal—loss of heating value, breakage of large sizes, and spontaneous combustion—are almost completely eliminated by strict adherence to the storing essentials, the report states.

Based on studies made at subbituminous coal storage sites of the Great Western Sugar Company, the report contains details of coal-storing techniques, together with gas analyses, changes in physical and chemical properties, temperature tables, pit construction data and several illustrations.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request

Boiler Feed Control

Bulletin No. 463 by Northern Equipment Company devotes 16 fully illustrated pages to the story of Copes boiler feedwater control at the Westover, Greenidge and Jennison Stations of the New York State Electric and Gas Corporation. Discussion of these controls is prefaced by descriptions of the boiler-room equipment of each of these stations, and significant data are given for each. Typical flow charts are included.

Steam Sales

"Steam Sales Improve Operation of Municipal Power Plant" is the title of a booklet just published by The Ric-wiL Company of Cleveland. It gives the case history of the Piqua Municipal Power system at Piqua, Ohio, which several years ago went into the business of selling steam to nearby industrial plants. The book outlines the advantages to a utility of selling steam in addition to electricity, and also the advantages to customers, namely, bringing power costs and manpower savings, and greatly reducing the smoke nuisance. The test tells how one plant was able to save over $20,000 per year in power costs by purchasing steam.

The book is illustrated with photographs and blueprints, and contains cost figures and other technical data. The story of the installation of underground steam conduit to serve steam customers is told in detail with many actual installation photographs.

Package Unit Demineralizer

A line of four package-unit demineralizers for providing industrially pure water at a fraction of distillation costs is described in Publication 4266 issued by Cochrane Corporation, Philadelphia. These units are designed for plug-in operation from any convenient 110-v 60-cycle source and are finished along the lines of modern refrigerators and other household appliances. They are constructed so that all steps of operation are performed and all results observed from a position in front of the panel. Chemical tanks are also charged from this position making the unit suitable for location against a wall or in a corner. All control valves and instruments are located on the panel at eye level. Various reaction materials are applicable to particular conditions and those best fitting raw water and effluent requirements are specified.

Blowdown Calculating Chart

The Water Treatment Division of the Magnus Chemical Company has just announced the availability of a new calculating chart for measuring concentration and blowdown in marine and stationary boilers. This chart makes it possible for the engineer to establish definite factors to aid him in fixing his blowdown rates and thereby bring about savings in fuel and in costs. It readily determines maximum permissible concentration of both suspended and dissolved solids for the operating pressure of the boiler and current load.

Per cent blowdown to maintain maximum permissible concentration is rapidly read on the chart, which also provides for blowdown chloride concentration where blowdown is controlled by maintaining a suitable chloride concentration.

Another feature of the chart is its ability to calculate blowdown from boiler pressure and blowdown valve size. It can also be used to measure condensate return against raw water makeup, using the chemical analysis for total solids as a basis for the calculation.

Try-Cocks

The Yarnall-Waring Company announces through Bulletin W6-1815 Yarway Sealtite Try-Cocks which are available for all boiler pressures. Included is a chart giving the installation dimensions, prices and parts list of these try-cocks.

Water Conditioning

The W. H. & L. D. Betz Company has published a booklet, "The Six Fundamentals of Betz Water Conditioning Service," which illustrates and describes the supervisory service they perform for boiler water conditioning. The procedure to be followed for trouble-free boiler plant operation is outlined step by step.

BOOKS

1— Piping Handbook 4th Edition

By Sabin Crocker

1376 Pages Price $7.50

This Piping Handbook shows to what extent piping has become a necessary science. The first 860 pages are mainly devoted to an exposition of the principles underlying the performance and structural design of pipes in general, while the remainder of the book covers in detail various piping systems such as were developed for power stations, hydraulic works, etc.

The laws governing the flow of fluids, such as gases, air, water, steam and oil, and their properties, are presented and discussed at length.

Following the laws of fluid dynamics is a brief, but valuable, chapter on the metallurgy of pipes and a complete collection of data on pipe fittings as they are now standardized by the various interested branches of industry.

Of necessity the chapter on heat insulation is short, but the information will enable the designer to solve a large percentage of his pipe insulation problems. Stress analysis of piping is treated in part graphically.

Mr. Crocker has enlarged on the practical application of piping by the addition of chapters on refrigeration and gas piping, corrosion, and hydraulic power transmission piping. The present edition is much more comprehensive than the 1930 edition.

2—Inspection Handbook for Manual Metal-Arc Welding

156 pages Price $1.50

This handbook, prepared by the American Welding Society, is the most complete and authoritative manual that has yet been published on welding inspection. It covers the requirements and duties of a welding inspector, methods of testing welds, and contains a comprehensive description of weld inspection by visual, magnetic-particle and radiographic methods. One section discusses the principal types of weld defects and indicates how they may be detected and corrected. The book is written in simple language and is intended to serve as a reliable source of information on any welding inspection problem.

3—Elementary Mechanics of Fluids

By Hunter Rouse

376 pages $6 \times 9^1/_4$ Price $4.00

The author has adopted a method of presentation differing from the conventional that is unique yet makes readily understandable the principles underlying the manifold uses in today's engineering of fluid flow. This is accomplished by development of the usual equations for flow of fluids starting from the basic equations of mechanics. Derivations are readily followed. Problems are included, both as examples of application of the text and of a nature akin to those the practicing engineer encounters.

The book contains eleven chapters, namely Introduction to the Study of Fluid Motion, Fluid Velocity and Acceleration, Pressure Variation in Accelerated Flow, Effects of Gravity on Fluid Motion, One Dimensional Method of Flow Analysis, Effects of Viscosity on Fluid Motion, Surface Resistance, Form Resistance, Lift and Propulsion, Surface Tension, The Role of Compressibility in Fluid Motion. There is also an appendix in which is summarized useful information on the application of the principles of dimensional analysis and on the mechanical properties of commonly used liquids and gases.

4—Statistical Thermodynamics

By Erwin Schrödinger

88 pages 5×7 Price $1.50

This is a course of seminar lectures delivered at the School of Theoretical Physics, Dublin Institute for Advanced Studies, the object of which, according to Professor Schrödinger, was "to develop briefly one simple, unified, standard method capable of dealing, without changing the fundamental attitude, with all cases and with every new problem that may arise." The text, which is far from elementary and comprises considerable mathematical analysis, is intended for the more advanced student of thermodynamics.

The author has condensed those topics which appear in many textbooks but has dealt at greater length with vital points which are usually passed over in all but large monographs. He discusses two different attitudes as regards the physical application of the mathematical result.

5—Thermodynamic Properties of Air

By Joseph H. Keenan and Joseph Kaye

73 pages $7^1/_2 \times 10$ Price $2.50

This book was brought out to meet the need for working tables on properties of air in connection with gas turbine studies, as well as in the solution of problems in regenerative heating and the expansion of air from states of high temperature. Included are values for viscosity, thermal conductivity conversion factors and tables and typical examples.

6—Graphical Symbols for Electric Power and Control

Price 40 cents

The American Standards Association recently issued these Graphical Symbols. Sponsored by the A.S.M.E. and A.I.E.E., these symbols were prepared by representatives of various bodies that have occasion to employ such symbols.

7— Water Treatment and Purification—2nd Edition

By William J. Ryan

270 pages Price $2.75

Since the publication of the first edition of this book, in 1937, considerable advancement has been made in water treatment and new or improved processes have been developed. The present edition attempts to bring the reader up to date.

The text includes chapters on: impurities in water; sedimentation and coagulation; filtration; analysis of water; lime and soda-ash process; ion exchangers; boiler feedwater treatment; disinfection of water; tastes and odors; miscellaneous treatments; and the prevention of corrosion. A general appendix contains tables of equivalents, conversion factors, atomic weights, compound formulas, and the more common chemical reactions associated with water treatment. Typical process equipment is illustrated.

For plant engineers and plant operators the value of the book lies in the fact that the author has succeeded in presenting the essentials of water treatment and purification in a readily understandable form. The book is not written for the chemist or water specialist, but rather for the engineer who needs a general knowledge of the subject.

COMBUSTION PUBLISHING COMPANY, Inc., **200 Madison Avenue, New York 16, N. Y.**

Enclosed find check for $. . . . . .for which send me the books listed by number.

NAME____________________ **Book Nos.**__________

ADDRESS____________________

Postage prepaid in the United States on all orders accompanied by remittance or amounting to five dollars or over.